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VOLUME 80 NUMBER 5

BULLETIN of the JOHNS HOPKINS HOSPITAL

THE PUBLICATION OF THE MEDICAL SCHOOL AND HOSPITAL
SUPPORTED BY THE DE LAMAR FUND OF THE JOHNS HOPKINS UNIVERSITY

May, 1947

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PUBLISHED MONTHLY
THE JOHNS HOPKINS PRESS, Baltimore-18, Maryland
Made in United States of America

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BULLETIN
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This periodical is issued monthly. Two volumes a year are issued, each consisting of approximately 400 pages, and beginning in January and July, respectively.

Subscription price. In the United States and its possessions $6.00 per year. In Canada $6.25 per year; in foreign countries $6.50 per year. Prices for back volumes and back single numbers on application. Single numbers of the current volume, when available, $.75. Prices are net, postpaid.

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THE JOHNS HOPKINS PRESS
BALTIMORE-18, MARYLAND, U. S. A.

Entered as second-class matter at the Baltimore, Md., Postoffice. Acceptance for mailing at special rate of postage provided for in Section 1103, act of October 3, 1917 Authorized on July 3, 1918.

IDIOPATHIC LOW BACK PAIN AND SCIATICA— 25 YEARS AGO AND NOW*

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St. Louis, Missouri

By the expression "low back pain" we mean pain situated and originating in the lumbosacral region, that is at the level of the 4th and 5th lumbar vertebrae and sacrum, and which is not due to obvious disease or fracture of the vertebrae in this region. This is an area which can be covered by the hand of the examining surgeon, yet one which has been the subject of much careful anatomical and clinical investigation and of even more romantic speculation. This region has received unusual attention because pain and disability in the low back is one of the most frequent afflictions of mankind. This low back pain may or may not be accompanied by sciatica.

The mode of onset, intensity and distribution of the pain and clinical course of the condition vary greatly among patients presenting the symptom complex which we term "low back pain." In part it is this great variation in the clinical picture presented by these patients which has accounted for the multiplicity of theoretical explanations of the condition.

During the period when we were in school most of these low back pains were believed to be due to strains or subluxations or arthritis of the sacro-iliac or lumbosacral joints. As nearly as I can determine, the tendency to favor one or the other of the above joints was dependent largely upon the geographical location of the observer rather than upon any clinical or pathological evidence of disease in the given joint. In Boston under the influence of Dr. Goldthwaite, and here in Baltimore under that of Dr. Baer the sacro-iliac joint was the overwhelming favorite and practically all cases of low back pain which could not be explained by fractures, neoplasms, spondylolisthesis or destructive disease of the vertebrae were believed to be due to lesions of the sacro-iliac joints.

In a paper published in 1917, Baer (1) likened sacro-iliac sprains to

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* Read before the Johns Hopkins Medical and Surgical Club, Feb. 27, 1947.

sprains of the ankle and stated that the ligaments holding the sacrum to the ilium could be wrenched, causing a strain or sprain of the sacro-iliac joint. Depending upon whether the sacrum was tilted backward or forward they were divided into types A and B. The type A sprain was characterized by a flat back and unilateral lumbosacral pain and often it was accompanied by referred pain in the distribution of the superior gluteal and sciatic nerves. It corresponded to the traumatic type of lumbosacral strain of other authors (Key (2)) and the type B sprain with hollow back and bilateral lumbosacral pain which was not referred was similar to the postural type of lumbosacral strain. It was stated that the diagnosis was quite simple and that lumbago is generally a strain of the sacro-iliac joint.

Those who believed that the pain originated in the sacro-iliac joints studied the anatomy and physiology of these joints and presented convincing arguments in support of the vulnerability of these joints to strain or subluxation and of the tendency of such injuries to cause pain in the distribution of the sciatic nerve either as referred pain or by direct irritation of the nerve roots as they crossed the joint. Smith-Petersen and Rodgers (3) studied the articular cartilage from some of the sacro-iliac joints and reported end results on 26 patients who were subjected to sacro-iliac arthrodesis for the cure of low back pain and sciatica. Some of the specimens exhibited evidence of traumatic arthritis, and the symptoms were relieved by the operation in 22 of the 26 patients, and were partly relieved in two others. Even more spectacular are the results reported by Baer (1). In the severe cases with marked disability and sciatic pain he advised manipulation under full anesthesia followed by immobilization for 10 days in a short plaster spica. The manipulation consisted of passive flexion of the affected hip with the knee straight, to well beyond 90°. This stretched the hamstring muscles and was believed to move the ilium backward on the sacrum and thus reduce the subluxation. Baer (1) stated that he had "manipulated 100 of these cases by this simple method with immediate relief in almost every case, and with a relapse in only three."

It would thus seem that the problem of low back pain and sciatica was solved satisfactorily 30 years ago. Indeed Baer stated "I know of no class of cases where the results obtained are so pleasing, both to the patient and to his physician." Unfortunately, neither the manipula-

tive treatment nor the arthrodesis nor even the incrimination of the sacro-iliac joint as the seat of the trouble has stood the test of time. Danforth and Wilson (4) in 1924 after careful anatomical studies of the low back and clinical observations on 21 patients, concluded that "the sciatic pain of the type studied is a symptom of disturbance in the lower lumbar spine and that the site of the lesion is most frequently in the lumbosacral junction and the nerve chiefly involved is the 5th lumbar."

As more orthopedic surgeons realized that they were failing to relieve many of their patients with low back pain and sciatica by therapy directed at the sacro-iliac joint their attention was shifted to the lumbosacral joints and braces were devised for their support and operations were performed for lumbosacral fusion (Williams (5)). The lumbosacral region offered an especially fertile field for speculation because congenital anomalies occur here more frequently than they do in any other part of the skeleton and in addition to the strains, subluxations and diseases which any joint might be heir to, this region presented a large number of anatomical variations which were thought to account for much of the pain originating in the low back. This was especially true of enlarged or partly sacralized transverse processes. Just as in the case of the sacro-iliac joint series of cases were reported in which low back pain and sciatica were relieved in almost every case by lumbosacral fusion.

However, this method too did not stand the test of time and many orthopedic surgeons were not satisfied with the results which they and their colleagues were obtaining in these cases. Having noted that the sciatic pain disappeared in a patient whose fascia lata he had divided for the correction of a flexion deformity of the hip, Ober (6) quickly convinced himself and many others that idiopathic low back pain and sciatica were caused by a tight iliotibial band and a great many patients were subjected to the operation of fasciotomy and many were reported to have experienced relief after the operation.

Again time proved that fasciotomy was not a panacea for low back pain and the operation was gradually abandoned, and the great majority of orthopedic surgeons continued to treat these patients conservatively. The type of conservative treatment depended upon whether or not the patient was so disabled that he was confined to his home or

preferably to a hospital. If so he was kept in a bed with a firm mattress and a fracture board beneath the mattress and a small pad or pillow beneath the lumbar spine and a moderate amount of traction might be applied to one or both legs. This was supplemented with local heat and sedatives as necessary for the relief of pain.

Other surgeons insisted that the lumbar spine should be maintained in flexion and the head and shoulders and knees were elevated. These patients were also subjected to various types of manipulation either with or without anesthesia and these manipulations might be repeated as often as seemed indicated. In some instances the spine was immobilized in a plaster of paris jacket or spica cast.

Ambulant patients were given support to the low back in the form of adhesive strapping, belts, corsets, plaster jackets or braces, and were advised to avoid subjecting the back to unusual strain, to avoid fatigue and to sleep on a firm bed with a fracture board beneath the mattress. They were given postural exercises and stretching exercises and the shoes were altered if this seemed indicated.

In addition to the above, physical therapy, especially local heat and massage and various types of manipulation without anesthesia were used to a variable degree. In any patient with acute low back pain the low back might be strapped firmly with adhesive, the strapping extending from the level of the trochanters upwards to grasp the lower ribs. This often afforded considerable relief whether the patient was confined to bed or ambulant, but precluded the use of local heat or massage.

In addition to the methods mentioned above, injections of novocaine into the lumbosacral region or into so-called trigger points, or epidurally through the sacral canal have been used extensively and such injections have been reported to have cured a high percentage of the patients in which they were used. Others injected air beneath the lumbar fascia and likewise reported that the patients were relieved of their symptoms.

Other reported causes of the low back pain and sciatica in a small percentage of cases were pressure by the pyriformis muscle on the sciatic nerve, adhesions or bands in the sacral canal especially in patients with spina bifida occulta, hypertrophied asymmetrical articular facets compressing one or more nerve roots, enlarged transverse proc-

esses pressing on a nerve root, kissing spinous processes or herniations of fat through the deep fascia, and it has been reported that surgical procedures directed at the removal of each of the above causes has resulted in the relief of the pain and disability in the patients who were operated upon. Finally in 1934 Mixter and Barr (7) published observations on a series of patients in whom protrusions of intervertebral discs had pressed upon the roots of spinal nerves and had caused pain in the low back and sciatic nerves and in some patients had also caused sensory and motor paralysis of such a degree that it could be detected upon neurological examination. They further showed that the protruding disc could usually be localized by spinograms after Lipiodol had been injected into the subarachnoid space, and that relief of the symptoms followed the surgical removal of the protruding disc.

It was immediately recognized that Mixter and Barr had made an important contribution to our knowledge of the cause and treatment of low back pain and sciatica and neurological surgeons accepted their work with enthusiasm and aggressively attacked the problem as it presented a new field for their surgical activities.

Orthopedic surgeons on the other hand who had been dealing with low back pain and sciatica for many years and had seen most of these patients get well under a wide variety of diagnoses and because of or in spite of many different forms of conservative and operative treatment were willing to admit that in a small percentage of the cases which presented the typical syndrome of low back pain with sciatica with neurological disturbances the symptoms might be due to protruding intervertebral discs, but they believed that the great majority of these cases were suffering from strains of subluxations or arthritis of the lumbosacral or sacro-iliac joints and they continued to treat these patients conservatively or by manipulation or fusion of the suspected joints. Especially did orthopedic surgeons object to the injection of Lipiodol into the subarachnoid space as they feared that this might cause meningeal irritation and add to the patient's trouble.

When Dandy (8) and some other surgeons had become sufficiently familiar with the clinical picture and operative findings in patients suffering from protrusions of intervertebral discs in the lumbosacral region to permit them to operate upon these patients without subjecting them to the injection of radio-opaque material into the subarach-

noid space, interest in these lesions broadened and evidence accumulated which indicated that lesions of the intervertebral discs were the most frequent causes of idiopathic low back pain. Key (9) stated that "the symptoms which we formerly attributed to sacro-iliac or lumbosacral strain, arthritis or subluxation, lumbosacral facet syndrome, postural strains of the low back, and myofascitis or fascitis in the lumbar region are really due to lesions of the intervertebral discs in this area." In a second provocative paper read before the 1944 meeting of the Southern Surgical Association, it was concluded that the conditions which we have called low back strains and classified as idiopathic low back pain are lesions of intervertebral discs in this area" (Key (10)).

When they were presented each of the above papers was subjected to considerable adverse criticism. Their contents were very much in line with opinions expressed by Walter Dandy (11) who has contributed so much of lasting value to our knowledge of intervertebral disc lesions. Almost three years after the above papers were written I am even more convinced that the apparently radical statements which they contained are correct. This opinion is based on the following:

1. In a high percentage of a relatively large series of personally studied and operated cases (about 400) in which the diagnosis was obtained from the history and physical and x-ray examination the preoperative diagnosis was proven to be correct when the spinal canal in the lower lumbar region was explored at the operation. Most of these patients were not subjected to spinograms before the operation and it was not possible always to localize the offending disc or discs with precision before the operation, but this was done by inspection and palpation at the operation. The suspected disc was exposed and if this appeared normal or not sufficiently abnormal to account for the symptoms the adjacent disc was exposed and examined. A satisfactory percentage of these patients are improved or relieved after the operation.

2. In many of these cases the patients were followed or seen at intervals over periods of months or years before they were operated upon and some of them were subjected to long continued conservative treatment. Over a period of time a given case might present various gradations between a normal back with no symptoms and a rigid flat back with a contra-lateral list and severe unilateral pain in the low back

which extended into the buttock and down the course of the sciatic nerve to the foot and this might be accompanied by sensory disturbance and loss of the ankle jerk on the affected side. The fact that in a given patient the clinical picture may vary so greatly from week to week or from day to day has not been sufficiently emphasized in the study of this condition.

3. In a large series of patients presenting the syndrome of idiopathic low back pain all gradations may be found between the patient who complains of occasional mild bilateral or midline lumbosacral pain which is not referred and is present only when he is tired and who is normal on physical and laboratory examinations and the patient who is completely disabled by severe low back pain and sciatica and who on physical examination presents the typical picture of a protruding intervertebral disc in the lumbosacral region. These variations of the pain among different patients in a series of patients with low back pain or from time to time in a given patient are explained more satisfactorily by an injured or diseased and protruding intervertebral disc than by any other pathological condition which is known to occur in the low back. And this opinion is confirmed by the patients who come to operation and in whom the protruding disc is found and removed and this is followed by relief of the patient's symptoms.

4. I have operated upon a moderate number of patients whose complaint was bilateral or midline pain in the lumbosacral region which was not referred, but was sufficiently troublesome and resistant to conservative treatment to warrant operation. These patients correspond to the group described by Dandy (11) as recurring low back ache without sciatica. Figures 1 and 2 reproduce a spinogram of such a case. This man had suffered from severe bilateral lumbosacral pain for several years and at no time had the pain radiated to either buttock or lower extremity. At operation a soft, fluctuant, dome-like, protruding disc was found in the midline at the 4th lumbar interspace as shown in the myelogram. However, since this man's local tenderness had been especially marked over the 5th lumbar disc, this also was examined and it was found that this disc was soft, fluctuant, dome-like, and protruded in the midline even more than did the 4th disc. This was not shown in the myelogram. Both protruding discs were removed and the patient made a rapid and complete recovery and writes

FIG. 1. SPINOGRAM OF PATIENT WITH CHRONIC BILATERAL LUMBOSACRAL PAIN WITHOUT SCIATICA. ANTERO-POSTERIOR VIEW, INDICATING MIDLINE PROTRUSION OF THE 4TH LUMBAR DISC

FIG. 2. SAME PATIENT—LATERAL VIEW, SHOWING PROTRUSIONS OF 3RD AND 4TH DISC

At operation a larger protrusion was found at the 5th disc which was tender before operation. Both 4th and 5th discs were removed and the patient's symptoms were relieved. The 3rd disc was not disturbed.

that he is having no pain in his low back. This patient and the myelogram thus prove three of the statements for which Dandy was criticized. These are:

a. Midline discs occur and may cause low back pain without sciatica.
b. The concealed or hidden discs may occur and cause symptoms, and
c. The myelogram may fail to show a protruding disc.

5. Failure of the myelogram to reveal a protruding disc is not conclusive evidence that such a disc may not be causing pain. Since we have learned to remove the pantopaque, Dr. Lee T. Ford and I have been using larger amounts of the radio-opaque material (9 to 15 ccm.) and studying the outline of the spinal canal with the patient standing as well as in various positions in recumbency. Even with this technique we have occasionally found errors in the myelograms, but the percentage of correct diagnoses by myelography which were proved at operation is relatively high.

6. The other alleged causes of idiopathic low back pain and sciatica are not based upon any proven pathological lesions. The ruptured or protruding intervertebral disc is the only pathological lesion which has been demonstrated to cause idiopathic low back pain and sciatica. When the disc material removed at operation was subjected to microscopic examination, degenerative changes were noted in about 50% of the specimens from a group of my cases (Eckert and Decker (12)). However, there was no correlation between the microscopic picture of the specimens and the symptoms or result obtained by the operation. This is to be expected if the symptoms are due to mechanical pressure or strain or to inflammation caused by these factors. When at operation the pain is found to be caused by pressure of an unrecognized metastatic carcinoma on a nerve root as occurred in two of my cases or to a tumor in the spinal canal as occurred in one of my cases the case is no longer one of idiopathic low back pain.

7. Failure to cure the patient by operation for removal of the offending disc is not acceptable evidence that a lesion of an intervertebral disc was not the cause of the pain. The offending disc may not have been found and removed or more disc material may have been extruded from the incompletely removed disc or a second protruding disc may be contributing to the patient's symptoms.

8. The fact that the symptoms may be relieved or not affected or made much worse by manipulations either without or with anesthesia is best explained by the possibility that the position of protruding disc material or of the nerve root may have been shifted by the manipulation. Can one imagine a sprained ankle or wrist being relieved by forcible manipulation? And in the case of the discs it makes no difference whether the manipulation was directed at the sacro-iliac joints, the lumbosacral joints or the lower lumbar discs, because it is not possible to manipulate one of these structures without applying force to the others in approximately the same degree.

9. The further fact that some patients who are temporarily relieved by manipulations gradually become worse after repeated manipulations and either suddenly or slowly arrive at a state where surgical removal of the protruding or extruded disc material is necessary if the patient is to be relieved of the pain is best explained by a disc lesion. All of us who deal with these patients have seen many of them with severe disc lesions who have been subjected to prolonged and repeated osteopathic or chiropractic manipulations for a low back pain which in the beginning was relatively mild and in no sense a condition for which operative treatment would be considered. I believe that the eventual severe disc lesion in many of these cases is caused by the repeated manipulations and that many disc operations would be avoided if rest and support to the low back were substituted for manipulation in the early or mild cases.

There is no doubt but that a high percentage of these disc lesions heal or at least the symptoms subside spontaneously.

It thus appears that in a patient suffering from low back pain with or without sciatica the first problem is to determine whether or not the pain originates in the low back. Usually this can be done by the history and physical examination. It is to be noted that the examination must be made while the patient is having pain or at least symptoms, otherwise it is apt to yield little information and it may be necessary for the patient to return one or more times for re-examination before it can be determined that the pain originates in the low back. Then if the x-ray reveals no evidence of spondylolisthesis or fracture or destructive disease or ankylosing arthritis the patient is assumed to be suffering from idiopathic low back pain and the burden of proof is on him

who says that this is not caused by a lesion of one or more of the intervertebral discs in this area.

The patient should then be treated conservatively along the lines mentioned in preceding paragraphs until he is relieved or until it is determined that his symptoms will not yield to conservative treatment and that they are sufficiently troublesome to justify a major surgical operation. Not until it is decided that operative treatment is indicated should he be subjected to a spinogram. This should be done when the surgeon desires to localize the protruding disc precisely before the operation and not for the diagnosis of a disc lesion. As much pantopaque as is considered advisable should be injected and this should be removed after the examination is completed. In my experience a spinogram is rarely necessary even in cases which are to be operated upon.

Even when the spinogram fails to reveal a protruding disc the operation for exploration of the canal and search for and removal of the offending disc should be performed if the patient's continued pain and disability justify the procedure.

Surgical treatment is reserved for those cases which fail to yield to conservative treatment and I wish that it were possible to state that the surgical removal of protruding discs will cure all of these patients with idiopathic low back pain. Unfortunately, there is a small group of not over 5% who are not helped by the operation and another group of about 20% who are only partly relieved. In the other 75% the results are very satisfactory.

It thus appears that in the treatment of idiopathic low back pain our best results today do not compare favorably with those obtained 25 years or more ago when many of these patients were treated by manipulations directed at the sacro-iliac joints or later by any one of several methods. For instance Baer's report indicates that he cured 97% of his cases by a simple manipulation of the sacro-iliac joint under anesthesia followed by immobilization for 10 days in a plaster cast. And now 30 years later we have abandoned that relatively simple procedure because we have found it ineffective and resort to a difficult major surgical operation and can cure only about 75% of the cases which we operate upon.

This apparent lack of progress is partly explained by a probable difference in the type of cases which comprise a given series. It is well

known that a large percentage of the patients with low back pain recover spontaneously without treatment or under a wide variety of methods of treatment. It is probable that most of the cases included in the earlier series would now get well under conservative treatment for the relief of idiopathic low back pain and we reserve our operative treatment for the small percentage of this large group of cases which suffer repeated or continued pain and disability and fail to respond to conservative treatment. It is our hope that with more experience the operative treatment may be improved to a point where our results will be even more satisfactory than they are now. It may be that in the next quarter century we will learn some other and more satisfactory solution to the problems presented by these lesions of the intervertebral discs. In the meantime we wish to emphasize the fact that a diagnosis of an intervertebral disc lesion does not mean that the patient should be operated upon and the offending disc or discs removed. The patient should first be treated conservatively and if this fails then the operation can be performed with a fair chance that it will be followed by relief of the pain. In my experience lumbosacral fusion is rarely necessary if the offending disc has been removed.

1. Baer, Wm. S.: Sacro-Iliac Strain. Bulletin of the Johns Hopkins Hospital, 1917, **28:** 159.
2. Key, J. Albert: Low Back Pain as Seen in an Orthopedic Clinic. Am. Journal Med. Sci., 1924, **168:** 526.
3. Smith-Petersen, M. N., and Rogers, Wm. A.: End-Result Study of Arthrodesis of the Sacro-Iliac Joint for Arthritis—Traumatic and Non-Traumatic. Journal of Bone & Joint Surgery, 1926, **8:** 118.
4. Danforth, M. S., and Wilson, P. D.: The Anatomy of the Lunbosacral Region in Relation to Sciatic Pain. Journal Bone & Joint Surgery, 1925, **7:** 109.
5. Williams, P. C.: Reduced Lumbosacral Joint Space; Its Relation to Sciatic Irritation. Journal of the American Medical Association, 1932, **99:** 1677.
6. Ober, F. R.: Relation of the Fascia Lata to Conditions in the Lower Part of the Back. Journal of American Medical Association, 1937, **109:** 554.
7. Mixter, W. J., and Barr, J. S.: Rupture of the Intervertebral Disc with Involvement of the Spinal Canal. New England Journal of Medicine, 1934, **211:** 210.
8. Dandy, W. E.: Concealed Ruptured Intervertebral Discs: a Plea for the Elimination of Contrast Mediums in Diagnosis. Journal of the American Medical Association, 1941, **117:** 84.

9. KEY, J. ALBERT: The Conservative and Operative Treatment of Lesions of the Intervertebral Discs in the Low Back. Surgery, 1945, **17:** 291.
10. KEY, J. ALBERT: Intervertebral Disc Lesions are the Most Common Cause of Low Back Pain with or without Sciatica. Annals of Surgery, 1945, **121:** 544.
11. DANDY, W. E.: Treatment of Recurring Attacks of Low Back Ache without Sciatica. Journal of the American Medical Association, 1944, **125:** 1175.
12. ECKERT, C. L., AND DECKER, A. M.: Pathological Changes in Intervertebral Discs. To be published in Journal of Bone & Joint Surgery, 1947.

THE ORIENTING REFLEX (QUESTIONING REACTION): CARDIAC, RESPIRATORY, SALIVARY AND MOTOR COMPONENTS

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In the functional study of the nervous system by the methods originated by Pavlov the quantitative ideal has determined the direction of many investigations. Some of the less readily measurable, or more complex, responses have thus suffered comparative neglect, in spite of their fundamental importance.

The purpose of this paper is to report in some quantitative detail upon a study of certain aspects of one of these complex behavior patterns—the one which has been variously called by Pavlov the "orienting reflex,"[1] the "investigatory reflex," the "focusing reflex."

In the description which Pavlov has given one will recognize a fundamental reaction pattern presented by a wide range of animals in reaction to a sudden change in the environment. The complexity and variability of this behavior pattern to a sudden new "stimulus" invites a corresponding variety of designations depending upon the aspect of the behavior which catches the observer's interest and attention. Pavlov, in "focusing" his attention upon the investigative behavior of his dogs aptly used the term "investigatory reflex." There is, however, a preliminary phase of the reaction in which investigatory behavior has not yet clearly crystallized—a phase which might be designated "questioning reaction" or, by Pavlov's own term, the "what-is-that reflex."

HISTORICAL

Pavlov first described in 1910 the reaction of the animal to a new stimulus as the "orienting or focusing reflex"; he considered it as a disturbance producing external inhibition of the conditional reflex (abbreviated cr).

"Every sound, be it ever so small, appearing in the midst of habitual sounds and noises which surround the dog, each weakening or reinforcing of these constant

[1] Abbreviated OR.

sounds, each change in the intensity of the room illumination (the sun becoming hidden by the clouds, a sunbeam suddenly breaking through, a flickering of the electric lamp, a shadow across the window), the appearance of a new odour in the room, a warm or cold current of air, something touching the skin of the dog, as a fly, or a falling speck of plaster from the ceiling—in all these and in endless like cases, there fatally begins an activity of one or another of the skeletal muscles of our animal, as of the eyelids, eyes, ears, nostrils; or the head or the trunk or some other part of the body will turn and take a new position; and these movements are either repeated and reinforced, or the animal becomes fixed in a certain pose.

"We have before us again a special reaction of the organism, a reflex of the simple kind which we call an *orienting* or *focusing* reflex. If in the surroundings of the animal there appears some new agent (by this I include changes in the intensity of previously acting agents), then the corresponding receptor surfaces of the organism become focused on it, in a manner which will bring about the most favourable stimulation." (Pavlov, "Lectures on Conditioned Reflexes," vol. I, N. Y. 1928, p. 134.

Any change in the environment—tactile, olfactory, auditory, visual —may elicit the OR. If the stimulus is too strong, instead of the OR there may be a startle reflex, or some marked emotional state as fear. A characteristic of the OR is that it tends to disappear with repetition, as the animal becomes accustomed to it.

In 1916 in the lecture *Reflex of Purpose* Pavlov added the word "investigatory reflex" and considered this reaction the basis of inquisitiveness, scientific research, etc.

"Now every new factor arising in the surroundings, if repeated at short intervals and unaccompanied by any further direct influence on the animal, becomes more and more indifferent. The orienting reflex which it calls out becomes weaker and finally disappears, and with it also disappears the inhibitory action on our conditioned reflex. On this extinction is based the fact that the constant composition of the surroundings remains without apparent effect on the animal." In addition to the orienting reflex: "All extremely strong stimuli, strong light, sudden noises, etc., provoke special reactions, as, for example, shivering or trembling of the animal, the reaction of running away, trying to break away from his stand, or the opposite cataleptic-like state; on the other hand, the sight and sound of persons having a certain relation to the experimental animal, or the sight and sound of other known animals, and various things of the same sort, condition every previously elaborated response on the part of the animal" (1).

The OR is often difficult to demonstrate unless other extraneous stimuli are excluded. Thus in an animal running about one may not see a reaction to new stimuli or even to loud noises, whereas in the experimental camera, one may usually see the animal or person turn his head to the slightest sound, light or tactile stimulus.

Pavlov noted that the OR inhibited both the excitatory cr (external inhibition) and the inhibitory cr (disinhibition) and it was to avoid such interferences that he built a sound proof camera.

For purposes of observation and reporting in this paper we use the term "orienting reflex." Whitehorn has suggested tentatively the use of the terms "questioning reaction," or "uncertainty reaction" thus stressing that aspect or phase of the reaction which was indicated by Pavlov's term "what-is-that" (Russian *shto takoe*) reflex. This aspect was emphasized by a student in this laboratory, unfamiliar with either the term or the reaction, who seeing it for the first time, said, "the dog looks as if he is asking a question."

In subsequent studies, it may prove useful to discriminate different phases by different terms.

By several criteria the OR may be considered an unconditional response; it occurs in many species, it is inborn and present without training, and it persists after ablation of the cortex. The peculiarity of the OR lies in the fact that in the intact animal it disappears or weakens after repetition of a given stimulus. Perhaps this characteristic could be more aptly expressed by saying that the stimulus to elicit a "questioning reaction" in a normal animal, must be continually new and different. The disappearance or weakening of the "questioning reaction" on repetition of the same stimulus may be considered as an instance of cortical or conditional inhibition, since such weakening does not occur in a decorticated animal. The "questioning reaction" may include as an element the startle reflex although it is not identical with this reflex.

The progressive decrease in intensity of the OR, i.e., its gradual extinction by repetitions of the same stimulus without the reinforcement provided by novelty, may be considered an adaptive process, but the exact extent and rate of its progress has not been measured heretofore owing to the lack of an adequate method. Pavlov studied this inhibition of the OR by simply observing the disappearance of the

motor investigatory components, and he also made attempts at quantitative study through measurements of the inhibiting effect of the OR on other conditional reflexes.

The study here reported is related to studies on cardiac conditional reflexes previously conducted in this laboratory.

In 1934 E. C. Andrus and Gantt began to study the possibility of forming cardiac conditional reflexes to peripheral nerve stimulation, and in 1939 Hoffmann and Gantt and in 1942 Dworkin and Gantt established the fact that the heart rate changed regularly during the action of a conditional stimulus signalizing either food or pain—in other words that there is a definite cardiac conditional reflex subject to general laws of learned behavior (2).

In further quantitative studies of cardiac reactions it has become necessary to learn how much of the animal's measured cardiac response to a conditional stimulus is a result of the conditioning process and how much might be attributable to the new stimulus itself (i.e. a part of the orienting reaction).

For these several reasons we have undertaken to investigate the normal course of reaction to a new stimulus. We have also compared the reaction to such a stimulus (both before and after the animal has become accustomed to it) with the reaction to the same stimulus after it has been made the conditional stimulus for some other specific reflex.

METHOD

Seven dogs were used in these experiments, six of them never having been worked with previously in the laboratory. The fact that Gosha and Connie had been fed in the experimental camera may have influenced some of the results. After a dog was well accustomed to the experimental environment, it was placed repeatedly in the experimental camera and a stimulus was given (tone, metronome, buzzer or light). These specific stimuli had not been used for any previous conditioning of these animals (except Connie, as noted below) nor were these stimuli, in this phase of the study, reinforced, that is, given in association with an unconditional stimulus for specific reflexes, such as ordinarily serves to establish a conditional reflex. Ten to forty repetitions of the new stimuli acting for 30 seconds were given on each

TABLE I

Gosha, 24 November 1944

Showing the reaction of the dog to neutral auditory stimuli (M40, Bu) beginning with the first time they were used

In the column "Control" the HR is given for the 10″ period immediately preceding the stimulus. In the "Cardiac OR" there are given in sequence the HRs for every 5″ while the auditory stimulus is acting. The italics in this column indicate that there is during the period of the italicized figure a motor component of the OR. The next column "UR" indicates the cardiac rates to the eating of 10 gms. of food taken every 5″ after the beginning of eating. The bold figures in this column show that the dog is in the act of eating for the period that these rates are taken. When the dog is licking the food box but not eating a star is placed beside the HR for that period. The last column "Interval" contains the HRs for 5″ periods immediately following the 30″ after the beginning of eating, or after the cessation of the auditory stimulus.

TIME	STIM.	NO. REP.	CONTROL	CARDIAC OR Q 5″						UR (10 GMS. FOOD)						INTERVAL Q 5″								
				0-5″	5-10″	10-15″	15-20″	20-25″	25-30″	0-5″	5-10″	10-15″	15-20″	20-25″	25-30″									
14:54	M40	1	74	*106*	*106*	*82*	*79*	*84*	*98*							92	77	83	78	79	77			
14:59	Fd.	—	77							**134**	**138**	114	86	82	78						73	82		
15:01	M40	2	83	94	*114*	*85*	*74*	*73*	*88*							77	88	78	72	78	73	77	77	
04	M40	3	70	*82*	80	73	77	77	73							66	71	78	72					
07	M40	4	74	*84*	94	118	108	96	88							68	73	94	78	76				
10	M40	5	73	*83*	78	70	74	74	70							83	73	79	62					
12	M40	6	73	*80*	74	74	64	72	73							66	68	86						
15	M40	7	74	90	94	90	97*	102*	78							74	74	62	73	70				
17	Bu	1	73	*91*	*133*	107	86	94	82							73	67	72	64					
19	Bu	2	67	*72*	*93*	*91*	*87*	*97*	*88*							80	74	74	79					
21	M40	8	80	*84*	77	101	94	77	71							85	64	66	64					
23	Fd.	—	62							**124**	**131**	110*	89*	96*	80	—	—	—	—					
27	M40	9	69	*72*	84	77	78	78	78							70	72	71	61					
30	M40	10	69	*73*	82	72	76	70	73							72	73	60	70					
32	M40	11	68	*70*	80	90	90	95	72							69	60	67	68	59	70	74		
35	M40	12	66	*77*	78	74	60	71	68							69	58	72	64					
38	Fd.	—	85							132	132	118	96	98	86	86	92	96	85	80	84	76		
41	M40	13	75	*91*	90	90	82	83	89							90	104	83	94	79	76	71	74	
44	M40	14	72	*76*	72	67	78	73	77							85	73	65	74					
47	M40	15	68	*74*	73	67	73	68	86							65	71	74	77					
49	M40	16	70	79	74	68	70	71	106							125*	93	84	79	82	76			
52	Bu	3	72	*78*	*79*	*72*	*72*	*71*	*74*							68	66	66	62	65	67			
54	Fd.	—	72							**120**	**138**	**98**	**82**	82	78	96	84	80	78	91	136	132		
58	M40	17	77	*95*	92	88	89	79	84							85	77	83	94	84	82	76		
16:01	M40	18	77	*82*	84	94	80	85	88							89	74	89	97	82	83			
03	M40	19	83	*86*	—	—	—	82	91							93	94	98	68	82	88	67		
08	M40	20	75	*77*	97	79	77	72	84							82	71	66	71	67				
12	M40	21	75	*66*	68	84	96	83	73							72	95	83	83	62				
16	Bu	4	72	*82*	74	72	76	74	77							75	70	77	73	67	72	66	70	71	68
18	Fd.	—	77							**121**	**120**	89	88	77	91	95	74	73	74	72	76	79	74	78
21	Bu	5	70	*84*	*88*	83	77	73	74							72	76	66	67	70	71	68		
24	Bu	6	67	*83*	84	79	70	74	79							68	72	68	71	66	78	88		
26	M40	22	80	88	76	80	88	82	92							77	74	79	77	84	100			
29	Bu	7	70	79	74	72	74	82	60							72	72	76	67	76	72	71	70	74
36	Fd.	—	70							**106**	**122**	**84**	86	74	91	85	77	85	86	98	73	94		
Av.	M40		73	83	84	82	81	79	82	123	130	102	87	85	84	80	76	77	74	76	80	80	72	74
	Bu		70	81	89	82	79	80	76															
S.D.	M40		5.1	8.7	10.7	12.7	11.6	8.6	10	10	7.7	14	4.8	10	6.2									

of three or four days at intervals of a few minutes until no marked changes (motor, cardiac, respiratory) occurred to the stimulus, or such changes were relatively constant. The reactions of the animals to the new stimuli were carefully noted—heart rates, duration and strength of motor ORs, latent periods,—and in two animals with chronic fistulae of the parotid gland, the salivation to the stimuli was measured. The heart rates were recorded with a Brush Oscillograph or a Parmenter Cardiotachometer and counted for 5 second periods as shown in Table I.

Gosha, a young active female Pit bull terrier was first brought into the laboratory 30 December 1943 and accustomed to the camera by bringing in and feeding it several times a week from the food box. (The early experiments were performed by Evelyn Whitehorn.) The dog was not brought into the camera again from 2 February 1944 until the 27 October 1944. It was brought into the camera 6 times for feeding between the 27 October 1944 and 24 November 1944, on which date the neutral stimuli (M40 and Bu) were introduced for the first time.

The dog was seen through a glass window of the camera separated from the experimenter. The time after the beginning of the stimulus when he turned or made any movement directed in a definite direction about the source of the stimulus was recorded as the latent period of the OR; the duration of this movement as well as its estimated intensity was also noted.

OBSERVATIONS

I. Motor Component of the Orienting Reaction. Ordinary observation of the OR is at best a rough estimation influenced by the experience and attitude of the observer. In this laboratory we evaluate the intensity of the dog's motor reaction (pricking of ears, turning to source, vocalization) on a four-point scale of intensity—a single plus (+) signifying a barely perceptible response, four plus (++++) an extremely strong response and ++ and +++ appropriate gradations ranging between.

In spite of the difficulties of evaluation involved, the pattern of change in the motor reaction was generally recognizable and paralleled roughly the extinction of the cardiac component of the reaction. The most marked reaction occurred the first time the stimulus was given,

and progressively diminished upon repetition during each session, and was found to be of low intensity even at the beginning of each new session, unless a long time intervened. A marked strengthening of the motor OR to a specific stimulus occurred for some minutes after food was given in the camera.

This pattern of extinction was followed in all dogs except Clare, whose motor reactions increased in intensity from day today. Until more evidence is accumulated on a large number of animals, it is of course impossible to draw conclusions about Clare's deviation from the usual course of the OR and its relation to her hyperreactivity later in the camera (which was so violent as to make her unsuitable for laboratory work).

Duration of the motor investigatory behavior is as difficult to estimate as strength, and does not follow any clearcut pattern. On the whole, however, it may be said that with repetition a definite trend of diminishing duration of the OR was perceptible in our dogs, the duration becoming shorter as the apparent "tension" of the dog's movements decreased.

The latent period of the motor OR is subject to the error of unaided observation. There is a large margin of error depending upon the judgment of the individual observer. This index was of little value in the present study. In general the stronger the motor components of the OR the shorter the latent period. But the latent period is not only a characteristic of each observer but of each individual dog as well as of the kind of stimulus used.

II. Salivation and the OR. There appears to be no special reason, a priori, why salivation should be considered a component of the OR, and our observations are not consistent with such a formulation, for there is little evidence of quantitative parallelism between salivary secretion and the OR; yet we have observed remarkable instances of some kind of a relationship. The stimulation of salivation by food or by conditional stimuli may markedly enhance the OR to a new stimulus, or revive an OR to a particular stimulus previously extinguished by repetition. Furthermore, in an experimental camera which has been used for salivary experiments, a new stimulus may elicit, along with the OR, a strong salivary response.[2] Some of the details

[2] The question remains undecided as to whether this so-called salivary component in Gosha is such a generalised conditional reflex in its incipient stage.

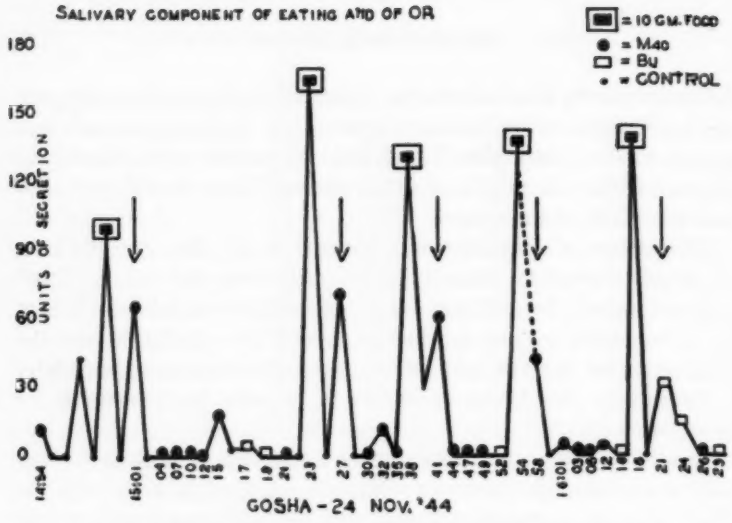

FIG. 1. SHOWING THE EFFECT OF FEEDING ON THE SALIVARY COMPONENT OF THE OR

Note increased salivation at the arrows pointing to the first neutral stimulus used after the feeding.

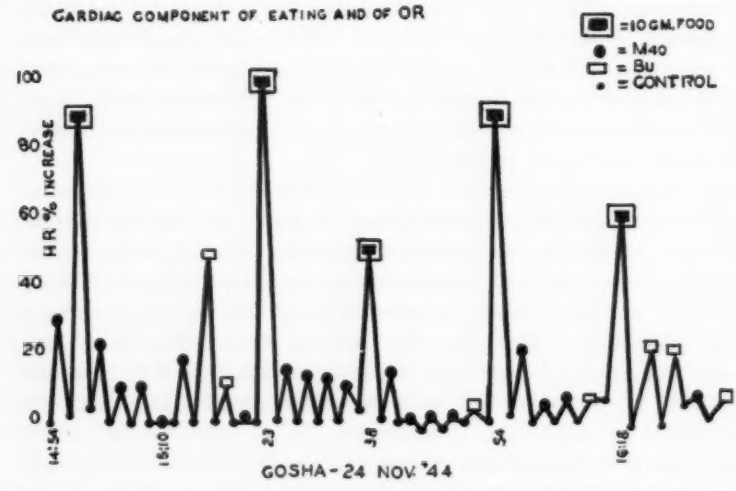

FIG. 1A. HEART RATE DURING EATING 10 GMS. FOOD AND DURING 3 SECOND ACTION OF NEUTRAL STIMULUS. CF. WITH FIG. 1

Note the decrease of the cardiac OR on successive repetitions of the neutral stimulus.

are reported below in connection with the cardiac component of the OR.

III. Respiratory Component of the OR. A respiratory conditional reflex has been noted by many authors (Pavlov, Kellogg, Liddell, Gantt et al.). There is also a respiratory[3] component of the OR, which is seen in Fig. 2. The respiratory component is less well marked, less abrupt than the cardiac component of this reaction, similar to

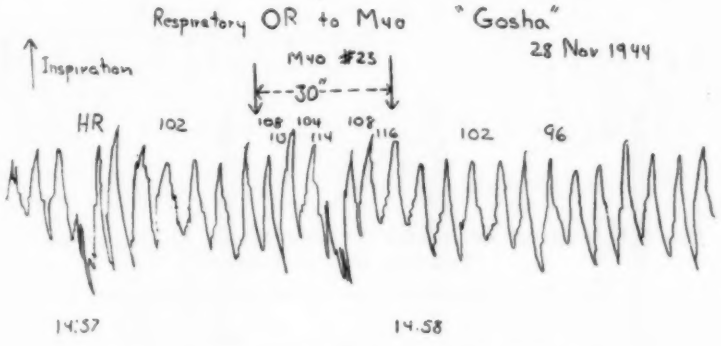

FIG. 2. RESPIRATORY OR TO NEUTRAL METRONOME (M40)
The heart rates are written in figures before, during and after the action of M40.

the difference between respiratory and cardiac components of an emotional state such as eating (Fig. 3).

In Fig. 4 we see the dropping out of the OR on repetition of the stimulus, in both respiratory and cardiac components. The respiratory movements are more readily observed and recorded than are the skeletal muscular movements but are not nearly so sensitive as the heart rates.

IV. Cardiac Component of the OR. We have found that change in heart rate is the most regular component of the OR. This was not our expectation nor original object of study in performing these experiments. Studying heart rate change in connection with the con-

[3] We deal here only with the *motor* component of the respiratory reflex, i.e., the movement of the external respiratory muscles. Obviously there are other respiratory components demanding investigation, such as the gaseous exchange.

ditioning process, we had found it necessary to investigate cardiac reactions to new stimuli or sudden changes in environment as a control study for other projects, but our experience has thrown the whole matter into unexpected perspective.

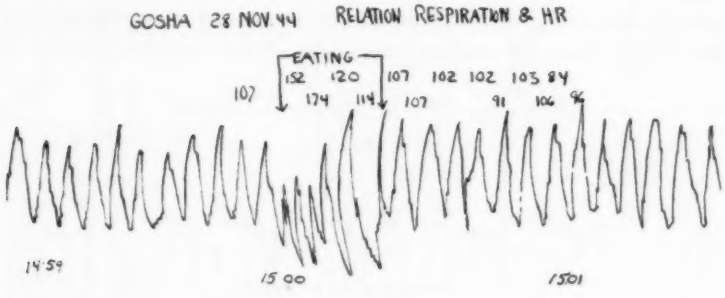

FIG. 3. RESPIRATORY AND CARDIAC CHANGES BEFORE, DURING, AND AFTER EATING 10 GMS. OF FOOD

The HRs are written in the appropriate places on the chart

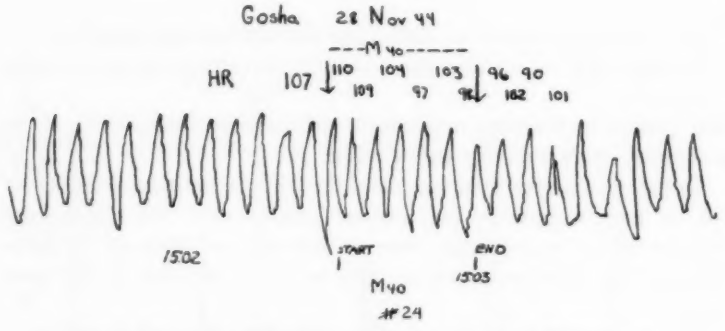

FIG. 4. SHOWING DISAPPEARANCE OF THE OR ON REPETITION

Cf. respiratory and cardiac reactions to M40 given for the 24th time, to M40 in Fig. 2 given for 23rd time five minutes previously.

In each dog studied in this series, changes in heart rate marked the occurrence of an OR, and reflected the course of its extinction, persistence, or recurrence. Fig. 5 and Table I illustrate the heart changes in one dog (Gosha) to three different new stimuli. This animal after

being accustomed to the experimental camera and eating from the foodbox[4] was stimulated for 10 seconds with a metronome of forty beats per minute (M40) and with the sound of air bubbling through water (Bu). Neither of these stimuli were followed by food. The progressive decrease in cardiac reaction to the new neutral stimulus is seen as the stimulus is repeated (Table I). After thirty repetitions

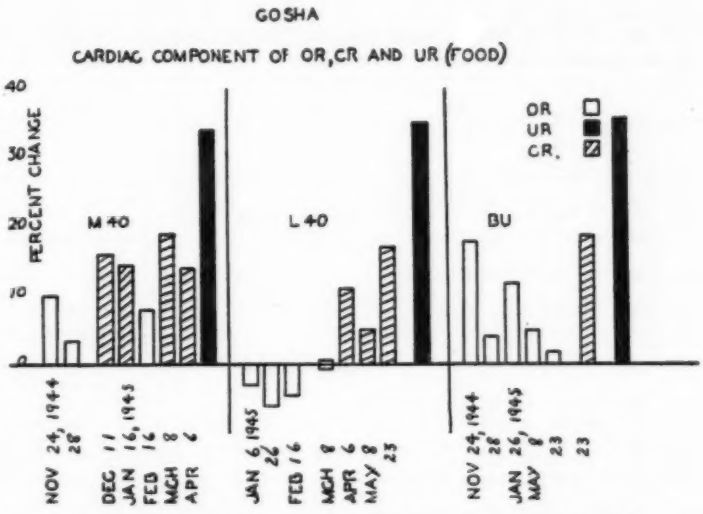

FIG. 5. CR. OF THE CARDIAC COMPONENTS OF THE OR, THE CR TO AUDITORY (M40 AND BU) AND VISUAL (L40) SIGNALS, AND TO UR, (EATING 10 GMS. FOOD)

The ordinates represent per cent changes in the heart rate from a base line of 100% control. The ordinates are for dates as marked.

of the stimulus (M40), during which the heart rate change decreased from 10% to less than 2%, M40 was then followed by two biscuits, resulting in a 72% increase in heart rate during the first 5″ of eating

[4] The practise of accustoming the animal to the unconditional stimulus alone (in this case food) before the studies of responses to neutral stimuli were made was later discontinued. For, if the food reaction (in this case) has been excited by the experimental environment (camera) *per se*, any new stimulus may release that excitement in the form of a simulated conditional salivary reflex.

(Table II). During a period thereafter when M40 was consistently employed and reinforced as a conditional food stimulus, it regularly

TABLE II

Gosha, 28 November 1944, Cardiac Rates

Symbols used are the same as in Table I with following additions. The figures in ( ) indicate that during this reading a small non-specific auditory stimulus was given—a click of a switch. In the second part of the Table the formerly neutral stimulus (M40) is reinforced, after it has acted for 30″, with 10 gms. of food. It is to be noted in this Table that the cardiac OR has nearly disappeared owing to repetition of the stimulus and that a cardiac cr is beginning to be formed.

TIME	STIM.	NO. REP.	CONTROL	OR						US (10 GM. Fd.)						INTERVAL						AV. INTERVAL
				0″					30″	0″					30″	0″					30″	
14:55	M40	23	92	*96*	93	91	114	96	106							90	94	89	90	—	—	91
15:00	Fd.		92							**154**	**163**	**115**	**114**	95	95	92	90	91	94	84	96	91
15:03	M40	24	97	*103*	*102*	91	91	91	89							86	90	90	91	86	86	
																96*						89
15:06	M40	25	90	*97*	98	95	84	85	91							88	98	89	91	88	82	
																90*						89
15:08	M40	26	93	*86*	*101*	*84*	90	92	94							80	88	88	86	88	85	86
15:11	M40	27	86	*82*	*88*	82	91	100	*85*							81	89	92	104	114	77	
																95	78	72*				89
15:14	Fd.		83							**146**	**(145)**	**96**	**89**	73	79	84	88	80	66	79	79	
																71	86	79	70*			78
15:17	M40	28	81	*86*	77	77	66	72	61							70	65	79	77	—	—	73
15:20	M40	29	74	67	79	82	80	92	95							79	88	66	74	64	80	75
15:23	Bu	8	73	*60*	*74*	*70*	66	74	76							63	82	60	84	79	77	74
15:25	Bu	9	74	*77*	64	66	74	72	67							68	76	62	73	73	83	73
15:28	M40	30	71	*73*	89	77	84	91	84							66	73	78	62	77	—	71
Av.	M40		86	86	91	85	88	90	88	150	154	106	102	84	87	79	85	80	83	83	83	82
Av.	Bu		74	*69*	*69*	68	70	73	72													
				Conditional Stimulus																		
									(83)													
15:31	M40	31	76	*72*	64	77	76	61	73	**(125)**	**114**	**91**	82	73	76	70	84	92	—	—	—	82
15:37	M40	32	75	84	84	—	—	—	—							(85)	72	72	68	64	—	72
15:41	M40	33	78	88	104	96	84	82	89	**136**	**142**	**110**	**100**									
15:45	M40	34	86	85	85	—	—	—	—	**134**	**135**	**111**	**102**	**90**								
15:48	M40	35	86	80	88	—	—	—	—	**126**	**116**	91	86									
15:53	M40	36	95	96	102	—	—	—	—							92	88	(89)	(89)	84	88	
																90	98	102	108	91	109*	
																79	88*					93
Av.			83	84	88	87	80	72	81	130	127	101	93	82	76	82	81	84	79	74	88	81

*Readings in this line are beyond the 30″ period.

elicited an OR with cardiac accelerations of about 15%. During this period a light blinking forty times per minute (L40) was presented as a new stimulus for ten seconds on certain days (results shown in Fig.

5), but it did not increase the heart rate, although it produced a very slight motor OR. Indeed the response to L40 was accompanied with a slight decrease in heart rate. After thirty repetitions of L40, it was then followed by two biscuits, exactly as with M40. Thereafter when L40 was consistently used as a conditional food stimulus it regularly elicited cardiac accelerations of about 10%. While L40 readily became a conditional stimulus for food, it was not as strong a conditional food stimulus as M40, nor did it have as much effect upon heart rate, after this initial use as a food signal. That visual signals do not produce as strong a cr for the dog as the auditory, even when the same unconditional stimulus is employed, was first noted in Pavlov's laboratory (1).

When L40 had been firmly established as a conditional food stimulus, the new auditory stimulus of air bubbling through water (Bu) was introduced, and repeated. The regular OR sequence was observed, a fairly marked initial reaction, diminishing on repetition of the stimulus. After nineteen repetitions without food, Bu was followed by two biscuits. Thereafter, as a conditional food stimulus, Bu elicited marked cardiac accelerations, about 18%, as shown in Fig. 5.

The effect on the heart rate of a lapse of time in restoring an extinguished OR is seen in Fig. 5 with Bu. On the 28th November 1944 the cardiac component of the OR had practically been extinguished. After two months without using this stimulus it was again used (on 26th January 1945) and the HR response was nearly as large as it was when first used on 24th November 1944.

The results of somewhat similar experiments on Connie, using the stimuli Bu and L40 are shown in Fig. 8. In this dog the HR response to new stimuli decreased sharply, rather than gradually, after the first time given on each trial day.

With two dogs (Connie and Harry) the cardiac response to the 10″ sounding of a buzzer was measured forty times. The intensity of the OR was markedly different in the two dogs, Harry showing much less reaction than Connie, but both showing the usual diminution of response as the novelty diminished. The buzzer was then made a conditional stimulus for artificial sexual excitation produced by peripheral stimulation. The increase in cardiac response after the buzzer had become a sexual conditional stimulus is shown diagramatically

in Fig. 5[5] (Harry). Connie on the contrary showed a slowing of heart rate to the buzzer when it was made a conditional sexual stimulus. These differences in reaction may be dependent on the temperament of the dog. Harry, who showed definite cardiac acceleration to sexual conditional stimuli, had extremely hypoactive ORs. This dog is a lethargic, slow moving animal of the extreme phlegmatic type, difficult to excite with any stimulus.[6]

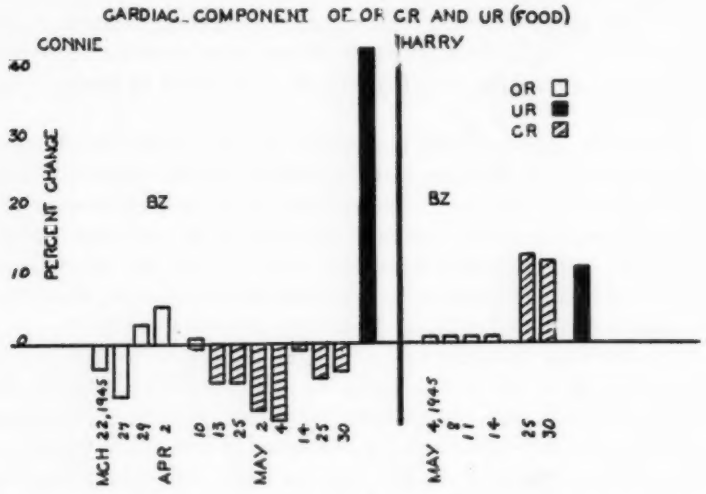

FIG. 6. COMPARISON OF CARDIAC ORS TO NEUTRAL SIGNALS WITH 1) CARDIAC CRS TO THE SAME SIGNALS AFTER BECOMING CONDITIONAL STIMULI FOR SEXUAL EXCITATION AND WITH 2) UNCONDITIONAL SEXUAL STIMULATION

The cardiac responses of two other animals (Tom and Clare) to a new stimulus are shown in Fig. 7. These dogs were accustomed to the camera, then repeatedly stimulated for 3 seconds with tones of

[5] This measurement of the cardiac component of the conditional sexual excitation is the first clear index which we have seen of artificial sexual conditioning based on peripheral stimulation.

[6] In other experiments, persistence and hyperintensity of the OR appeared to be a sensitive indicator of general hyper-reactivity.

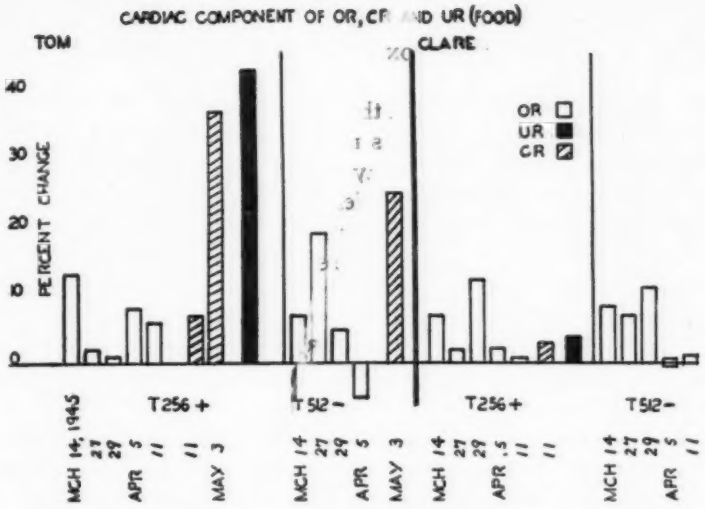

FIG. 7. COMPARISON OF CARDIAC COMPONENTS OF ORs TO NEUTRAL SIGNALS (TONE) WITH 1) THE SAME SIGNALS USED AS EXCITATORY (T256) AND INHIBITORY (T512) CRS AND WITH 2) THE EATING OF 10 GMS. OF FOOD (UR)

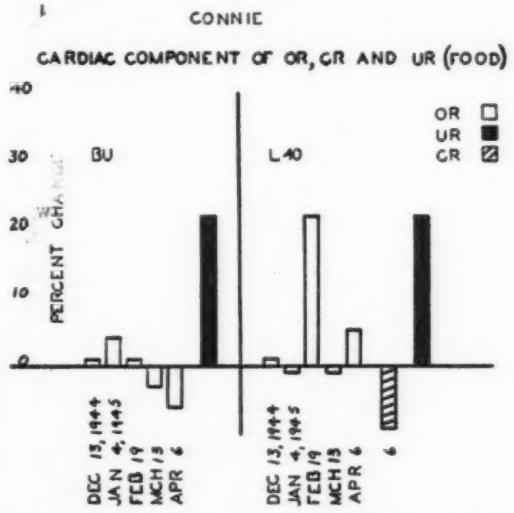

FIG. 8. CARDIAC COMPONENTS TO AUDITORY (BU) AND TO VISUAL (L40) NEUTRAL STIMULI COMPARED WITH THE CARDIAC COMPONENT OF THE CR AND UR TO FOOD

256 and 512 vibrations per second. In both cases the OR to the new stimulus diminished with repetition, altho in a varying degree and pattern in each animal. After approximately thirty repetitions of each tone, T256 was followed by a light electric shock to the foot, while T512 was given as before without reinforcement. Generalization of excitation extending to the conditional stimulus (T512) before differentiation is also apparent. In the dog Tom a marked OR was thereafter elicited by T256. The motor component of the OR diminished as usual on repetition, but the heart rate response continued to be large, as shown in the experiment of May 3 after forty-five combinations of T256 with shock.

The dog Clare went through an identical control period and conditioning process, with results shown in Fig. 7. Altho a slight conditioning occurred on March 11, this dog had to be discarded soon after, as she began struggling violently and continuously in the camera and could not be used for experimental work.

OR in Decorticated Dogs. Pavlov had previously noted the existence of the OR in decorticated animals, and its failure to be extinguished on repetition of the stimulus. Altho we did not have any completely decorticated animals in this series; two of our dogs (Checkers and Crazy) had been completely decorticated on one side, and on the other side the gyrus fornicatus on the mesial surface had been extirpated.[7]

These two dogs gave ORs which were not characteristically different in either the motor or the cardiac components from those of normal animals. In Checkers the cardiac OR to a tone of 256 vibrations acting for 5 seconds was characterized by an increase in heart rate from 120 to 140 (average of first eight readings). In Crazy the heart rate decreased from 95 to 86 on the first day the tone was tried (average of 22 repetitions of the tone on 5 November 1946), and from 92 to 89 on the 12 December 1946 (average of 20 repetitions of the tone). This animal shows less cardiac change to subsequent repetitions than he does to the first repetitions, as would be expected in a normal animal.

Startle Reflex. Altho the role of the startle reflex in the OR has not been investigated, there is nevertheless evidence of a relationship. Hunt says:

[7] These dogs, which had been prepared for other experiments, are to be reported in detail with Dr. Clinton Woolsey in further studies on the relation of cortex to cardiac reactions.

"It would also be possible to interpret the startle pattern as an orienting reflex in itself. Witness the way that in animals the generalized flexion seems to place the animal in a posture particularly suitable for the initiation of flight. I suppose, too, that when Kurt Goldstein speaks of startle as a catastrophic response, he is also in one way thinking of it as an orienting reflex.

"In connection with out studies in the startle pattern, we did find in the course of extinguishing it that it was subject to disinhibition by other stimuli."[8]

In spite of the fact that the startle reflex may play a role in the OR, there are marked differences. The former is a sharp, brief, non-directed movement, often appearing to the naked eye as a jerk, completed in 0.3 to 1.5 seconds. In contrast to the OR the startle reflex as described by Hunt and Landis has a definite pattern "beginning with the eye blink and passing downward over the body. The response is too rapid for the eye, coming and going in less than ½ second . . . the initial pattern was followed by less rapid secondary responses, viz., orientation to the position of the stimulus" (3). The movement in the OR, however, is specifically directed toward the source of the stimulus—an alert, forward, steady, focusing—aptly described by Pavlov as the "what-is-that" reflex. Furthermore the question of cardiac changes accompanying the startle reflex has not been definitely settled. Professor Hunt writes (to WHG) on 7 January 1947: "It was my opinion that while the cardiac reaction did not show uniformities of response, a more subtle analysis in the future might reveal such uniformities." There is an indication from the work of Landis and Slight (4) that the pulse rate increases but Landis and Forbes (5) state it is influenced by the phase of the cardiac cycle during which the stimulation takes place. Since they were measuring reactions that occurred in less than a second, they could not be certain that HR changes were elements of the primary startle pattern.

Some indication of the difference in the cardiac rates *following* a startle reflex and those accompanying the OR are shown in Fig. 9: there is a sudden and marked rise in HR to a stimulus (click of a switch) which elicited at 2 a quick undirected jerk of the dog (startle reflex) without further change, contrasted with the same stimulus which for some reason elicited an OR at 1 and 3.

Whitehorn found in the human being to a "startling stimulus" "only a slight or questionable emotional change and the heart record

[8] Personal letter to one of the authors (W. H. G.) 20 January, 1947.

showed little if any deviation from its previous character" (6). His results in patients are comparable to the small heart rate changes with the OR which we found in some dogs, eg. Harry, who later gave a strong OR and also became neurotic.

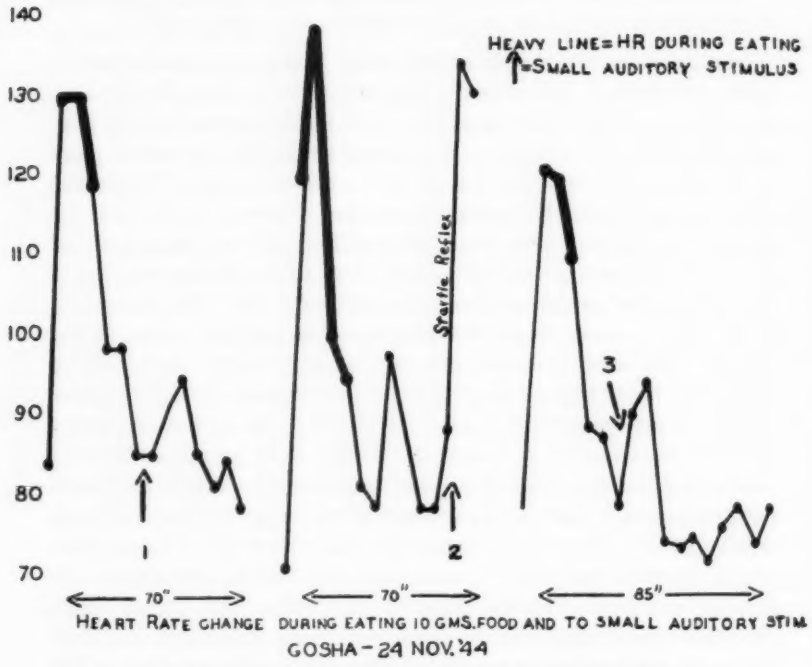

FIG. 9. COMPARISON OF CARDIAC RATES BEFORE, DURING, AND AFTER EATING 10 GMS. OF FOOD WITH A NEUTRAL STIMULUS INTRODUCED AT 1, 2, & 3

Note the difference in reaction to the neutral stimulus depending upon "the state of the animal."

OR AND TEMPERAMENT

Both the motor and cardiac components of the OR as seen in the figs. vary from dog to dog as well as with different stimuli. In general a dog that gives a strong OR to one stimulus will give a strong OR to

all stimuli. The most phlegmatic dog Harry—a very slow moving lethargic type hound—did not give an OR judged by heart rate tho he did in movement to two tones and a buzzer. On the other hand most dogs considered excitable in their ordinary behavior show a definite OR both motor and cardiac. The question of temperament is a complex one, and a satisfactory means of studying temperaments has not been seen in this laboratory.

COMPARISON OF CARDIAC AND MOTOR COMPONENTS OF THE ORIENTING REFLEX

Tables I and II show the parallel readings of the HR and the observed motor components of the OR. In Table I the HRs during which there was a motor OR observed, i.e., a turning of the dog or other directed movement, are in italics; with stimulus number 1 for example, there is a motor OR during the whole 30 seconds but the HR fluctuates from 106 at the beginning to a low point of 79 between 15 and 20 seconds.[9] An examination of these records show that the HR may go up without a movement being made and that vice versa a movement may continue without increase of HR; there is not always a temporal parallelism between the cardiac and the motor component. In general the cardiac component appears earlier than the motor. Thus with stimulus number 3 the HR goes up from 83 to 94 within 5 seconds while there is no movement made until 8 seconds, and tho the movement continued unchanged until the end of the metronome the HR drops from a peak of 114 at 10″ to 73 at 25″.[10]

In general, however, one finds a high correlation between the observation of the motor components of the OR and the heart rates recorded during the time of these movements. We find in the dog Gosha those movements marked "strong" accompanied by heart rate of 91 (median of eight 5 second readings); movements marked "medium intensity" by HR of 86 (median of sixteen 5 second readings);

[9] Also those HRs coinciding with the eating movements (chewing, swallowing) are in bold face in the column "Food," and the HRs during the act of licking the food box (without food) are starred.

[10] Both Whitehorn (6) and Hoffman (unpublished data from this laboratory) have shown that heart rate changes more often precede than accompany simple changes in position where there is no apparent motivation.

movements marked "weak" by HR of 80 (median of twenty-four 5 second readings). (The observed movements were marked without knowledge of the heart rates). There is thus a close parallel between the intensity of the motor and cardiac components in a given animal.

RELATIONSHIPS BETWEEN OR, CRS AND OTHER FACTORS

How one and the same stimulus may produce varying effects at different times depending on some unknown factor, most probably the *state of the animal*,[11] is seen in Fig. 9 when at one moment a slight clicking noise produces an OR and a few minutes later in the same animal a startle reflex with markedly higher HR. It appears that the state of alertness of the animal, the mood or attitude, the previous stimuli, the degree of hunger and a number of such factors may determine whether a new stimulus will elicit an OR or some other type of response.

The OR to a new stimulus modifies the other responses of a subject depending upon temporal relations determining the state of the organism. If the new stimulus elicits an OR during the early part of a delayed cr it inhibits the inhibition (disinhibition) resulting in a prompt appearance of the cr which is normally inhibited during the first stage of the delayed cr. If the new stimulus elicits an OR during the second stage of a delayed cr, i.e., when the cr is appearing, the OR inhibits the activity, resulting in a complete inhibitory state (7).

In the previous pages are numerous observations on the relationships between salivary reactions and the OR. These facts are of interest not only in connection with the OR but as evidence of the importance of the state of the organism for determining what effect a given stimulus will have.

DISCUSSION

The cardiac component of the OR is of interest therefore for both a description of the OR and in the detailed study of the cardiac crs. Previously the OR (reaction of the animal to a new stimulus or change of the environment) could not be evaluated because of the crude method of measurement—the casual observation of ordinary move-

[11] This term is used to cover factors *probably* in the animal, not always known, when the external environment is kept apparently constant.

ments. The study of the cardiac component provides not only a quantitative objective measure but a more complete picture of what is happening to the organism. Although the cardiac is probably the most reliable index, a consideration of all the components (motor, salivary, respiratory, cardiac) is not to be minimized.

The comparison of the various components of the OR present a somewhat varying picture depending upon what measures we use: if we adhered to any one component we would come to slightly differing conclusions. Synthesizing the components we arrive at a point similar to what obtains with a repeating decimal: the more measures we take the nearer we come to the truth and though we can approach the real answer we can never arrive at it completely. An increase in the number of components that are objectively recorded always brings us closer and closer to the whole picture and even though our synthesis can never correspond exactly to the thing represented it may, provided we are careful, serve our practical purposes.

In animals subjected to severe nervous strain in the laboratory we have observed the reappearance of an OR which had been inhibited, or a marked increase in its intensity, if only partially inhibited, and in nervous patients we have noted exaggerated ORs. Such observations have led us to suspect that the persistence of a strong OR may be an indication of susceptibility to breakdown, or its reappearance may be a symptom of approaching acute nervous disturbance, as well as a pattern of uninhibited reactivity. It is usually exaggerated in anxiety states. In World War II, in soldiers returned from combat, with acute neurotic breakdown, but not in non-neurotic soldiers returning from combat, it was frequently noted that there were exaggerated responses to neutral stimuli—startle, tremor and somatic complaints, alteration of heart rates and of respiratory patterns.[12] Perhaps these reactions are components or phases of an orienting reflex.

The reappearance of the OR under nervous stress may represent a disinhibition of cortical inhibition, releasing the subcortical reflex (OR). It may be a result of the general weakening of cortical processes,

[12] The valuable observations made by Victor H. Rosen and W. G. Reese on such soldiers are the basis of the above statement. These will be published in detail. I am indebted to Dr. Rosen for the account.

the most labile of which are the inhibitory. Thus we see the ORs becoming prominent during certain stages of the action of alcohol (8, 9), or of narcotics. Wolff and Gantt (10) have noted the appearance of the formerly inhibited ORs in both the incipient and emerging stages of anesthesia just at the time the crs were disappearing or as they began to reappear.

From the marked increase in HR to new and unaccustomed stimuli (auditory, visual) or to simply a change of environment it is apparent how a normal heart can be stimulated and a failing heart possibly placed under a burden by any quick changes of the environment, and by the law of extinction of the OR through repetition how the city dweller remains less stimulated by the metropolitan routine than the rural visitor. This brings up such questions as what constitutes healthy and beneficial and what harmful stimulation for the normal as well as for the pathological heart?

SUMMARY

A stimulus which had no previous known association for the dog produced in most animals an "orientation" toward the stimulus (turning, pricking ears, etc.). This orienting reflex was characterized by directed muscular movements, and by respiratory, salivary, and cardiac reactions, which were present even in dogs deprived of most of the cortex. The cardiac is the most definite, the most constant and the most easily evaluated of all these reactions. The OR disappears in most individuals (both dog and human) after several or more repetitions of the neutral stimulus; its persistence, a sign of hyperreactivity, is seen in both animals and patients.

We desire to thank Dr. Whitehorn for his suggestions, and for his generous help in the organization of the data of this paper.

REFERENCES

1. Pavlov, I. P.: Lectures on Conditioned Reflexes. (Tr. Gantt) International Publishers, N. Y., 1928, vol. I, p. 134.
2. Gantt, W. H.: Experimental Basis for Neurotic Behavior. Hoeber and Co., N. Y., 1944.
3. Landis, C., and Hunt, W. A.: The Startle Pattern. Farrar & Rinehart, Inc., N. Y., 1939.
4. Landis, C., and Slight, D.: Studies of Emotional Reactions: VI. Cardiac Responses. J. Gen. Psychol., 1929, **2**: 413–20.

5. LANDIS, C., AND FORBES, T. W.: The Relation of the Startle Reactions to the Cardiac Cycle. Psychiat. Quart., 1934, **8:** 235–42.
6. WHITEHORN, J. C., KAUFMAN, M. R., AND THOMAS, J. M.: Heart Rate in Relation to Emotional Disturbances. Arch. Neurol. and Psychiat., April, 1935, **33:** 712–731.
7. PAVLOV, I. P.: Conditioned Reflexes. (Tr. Anrep) London, 1927, p. 98.
8. GANTT, W. H.: Effect of Alcohol on Cortical and Subcortical Activity Measured by the Conditioned Reflex. Bull. Johns Hopkins Hosp., 1935, **56:** no. 2, 61–83.
9. FINKELSTEIN, N., ALPERN, B., AND GANTT, W. H.: Amphetamine (Benzedrine) Sulfate upon Higher Nervous Activity Compared with Alcohol. Bull. Johns Hopkins Hosp., 1945, **76:** no. 2, 61–74.
10. WOLFF, H. G., AND GANTT, W. H.: Caffeine Sodiobenzoate, Sodium Iso-Amylethyl Barbiturate, Sodium Bromide and Chloral Hydrate. Arch. Neurol. and Psychiat., 1935, **33:** 1030–1057.

NEURINOMAS OF THE CEREBELLOPONTILE RECESS

A Clinical Study of One Hundred and Sixty Cases Including Operative Mortality and End Results

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Neurinomas of the cerebellopontile recess have been the subject of magnificant monographs (5, 18) in which the so-called syndrome of the cerebellopontile angle has been elucidated. In the course of clinical studies of patients with proven neurinomas, we have found such wide variations in the incidence, chronology of symptoms and signs that we deemed it worthwhile to review all the cases operated on at the Johns Hopkins Hospital in a period of twenty years. In a subsequent communication we shall analyze all other tumors seen in this location in the same period in order to clarify the differential diagnosis.

From 1926 to 1945 a total of one hundred and sixty cases of neurinomas of the cerebellopontile recess have been found at operation. The operation was performed in almost every instance by Dr. Walter E. Dandy.

The accompanying table will give the relative incidence of these tumors in regard to the cranial nerves affected as well as their solitary or multiple locations.

UNILATERAL ACOUSTIC NEURINOMAS

It is common knowledge that neurinomas occurring in the posterior fossa originate predominantly from the VIIIth N., and in our series there were 145 (90 per cent).

Etiology: The relationship of trauma and infection in precipitating symptoms have been emphasized sporadically in the literature. Twenty-one cases (13.8 per cent) gave a history of infection or trauma coincidental to the initiation of symptoms. In ten of them there was definite history of middle ear infection on the same side as the lesion. Three cases dated their symptoms from an attack of influenza and one during the course of typhoid fever. Five gave a history of trauma on the affected side of the head with transient loss of consciousness and two related their impairment of hearing to pistol shooting.

Many arguments have been put forward that neurinomas at the angle are a manifestation of von Recklinghausen's disease. However, one marvels at the low incidence of peripheral lesions in this series, only three such cases occurring in this group. These shall be discussed separately due to some important clinical differences.

The hereditary tendency of these tumors has also been mentioned, but not a single instance of these one hundred and forty-five cases was encountered in contradistinction to the bilateral tumors where this tendency appears to be quite definite.

Incidence: 1. Sex: Ninety-one females (62.8 per cent) and fifty-four males (37.2 per cent) were affected. Why females should be more

TABLE 1

Neurinomas of the cerebellopontile angle

Unilateral acoustic neurinomas	145
Bilateral acoustic neurinomas	6
Unilateral acoustic neurinomas and von Recklinghausen's neurofibromatosis	3
Neurinomas of the Vth N.	3
Neurinomas of the Xth N.	2
Neurinomas of the XIth N.	1
Total	160

predisposed to these neoplasms is not apparent, but this is also true in the meningiomas and in many of the gliomas in this location. These figures correspond closely with those given by Cushing (5) and Olivecrona (24), but not by Henschen (18) who found no definite predisposition.

2. Location: There was no significant predilection of sides. 46.9 per cent were present on the right and 53.1 per cent on the left.

3. Age: The average age on admission was 44.1 years, the youngest 19 and the oldest 69. However, the average age at the onset of symptoms was much earlier; e.g., 39.6 years, the youngest 12 and the oldest 69. Consequently, an average of 4.5 years has elapsed between the onset of symptoms and the time of admission to the hospital, the shortest being 6 weeks and the longest 20 years. These figures are a little higher than Cushing's (5) who gives 38.1 years as the average age on admission and 34.1 years as the age of onset (30 cases). These

figures should be remembered in discussing other tumors at the angle as they may be of importance with respect to differential diagnosis.

Chronology of Symptoms: Since the publication of Cushing's classical dissertation on acoustic tumors emphasis has been placed repeatedly on the chronology of symptoms postulated by him, namely: 1. Auditory and labyrinthine manifestations; 2. the occipito frontal pains with suboccipital discomfort; 3. the incoordination and instability of cerebellar origin; 4. the evidences of involvement of adjacent cranial nerves; 5. the indications of increased intracranial pressure with a choked disk and its consequences; 6. dysarthria, dysphagia and finally so-called cerebellar crises and respiratory difficulties. Nielsen (24), in reviewing Olivecrona's 130 cases, points out that most of his cases followed this pattern and Olsen and Horrax (25) in their series of 52 cases found out that this chronologic order of symptoms was almost infallible. They concluded that if the complex of symptoms was not typical some other type of tumor was likely to be present.

In a careful review of our cases we find a great variance in the chronologic order and no definite pattern can be discovered. Only 45 cases (31 per cent) followed the chronology postulated by Cushing. In 30 per cent the Vth N. was affected shortly after the onset of auditory and labyrinthine disturbances. Incoordination and other manifestations of involvement of the cerebellar pathways followed symptoms referable to the VIIIth N. in 20.7 per cent. Headaches, occipital pains or suboccipital discomforts preceded even the auditory manifestations in 12.4 per cent and in 6 per cent no definite pattern was followed. This great variation may be easily explained by the relative vicinity of the anatomical structures at the cerebellopontile recess, by variation in the degree and direction of the growth and by individual anatomical differences.

Subjective Disturbances: Auditory and labyrinthine: Subjective evidence of either auditory or labyrinthine disturbances was present in every case. History of diminution of hearing was elicited in all but one, in spite of the fact that there was no objective evidence of hearing loss in five, as we shall see later.

Tinnitus was present in 62.3 per cent, being bilateral in nine and contralateral in three. It usually appeared simultaneously with the subjective impairment of hearing, less frequently followed it and

rarely preceded it. In only one case tinnitus was present without appreciable loss of hearing.

Dizziness was elicited in 40.8 per cent, far less frequent than tinnitus. In half of the cases it was described as true rotary vertigo and in the rest as a sensation of subjective dizziness or loss of balance. Dizziness usually followed impairment of hearing, occurring less frequently before or simultaneously.

Auditory and labyrinthine disturbances represented the initial symptom in 68.6 per cent of the cases, in four of which they represented the only symptoms present on admission and were operated on subsequently with the preoperative diagnosis of Ménière's disease.

Cerebellar: Cerebellar symptoms were next in order of frequency in this series. They occurred in 86.2 per cent and usually affected the upper and lower extremities on the same side as the lesion. The usual complaint was either unsteadiness in walking, staggering or clumsiness of one extremity. Three cases gave a history of bilateral cerebellar involvement, one of disturbances on the contralateral side and in three incoordination of the ipsilateral arm alone. In 3.1 per cent cerebellar disturbances were the initial symptom. The average duration of cerebellar symptoms was 8 months and the average time interval between the acoustic disturbances and these manifestations was 3 years.

Headaches: They were slightly less frequent than the cerebellar disturbances, occurring in 68.2 per cent. They represented the initial symptom in 12.4 per cent. The headaches were mostly localized in the occipital region, although at times they were described as suboccipital discomfort or pain behind the ear. In other instances they tended to radiate to the frontal region on the homolateral side; this type of radiation being present in half the cases. In eighteen cases the headaches were generalized and in nineteen cases they were only bifrontal. Vertical headaches or a sensation of fullness in the head were experienced in four cases. Curiously enough, in only sixteen cases the headaches were increased by coughing, sneezing and straining, contrary to the experience of other observers.

The average duration was 1.5 years and the interval between the onset of headache and the auditory disturbances was 3.3 years.

The relationship between headaches and pressure upon the trigeminal

nerve has been mentioned by others (25), and we thought it interesting to try to correlate these symptoms. In one hundred and twenty-one cases (83.5 per cent) headaches and trigeminal symptoms existed together or separately. Headaches preceded Vth N. symptoms in thirty-one cases with an average interval of 1.9 years. On the other hand, Vth N. symptoms preceded headaches in twenty cases with an average interval of 2.2 years. Headaches were present without trigeminal mainifestations in forty patients and converesely trigeminal symptoms occurred without headaches in twenty-two. Both symptoms appeared simultaneously in only eight cases. This correlation of figures would tend to disprove the previous assertion, but one is struck immediately with the similarity of the duration of headaches and trigeminal symptoms, e.g., 1.5 and 1.6 years, respectively, as well as the time interval between these symptoms and the acoustic disturbances, 3.3 years in each instance. Then these figures would tend to show that pressure of the neoplasm on the Vth. N. might be manifested by headaches or by disturbances in the sensory distribution of this nerve on the face, although one cannot escape the fact that acoustic tumor headaches may also be produced by pressure on the neighboring meninges, vessels and possibly on the IXth N.

Trigeminal: Symptoms referable to involvement of the trigeminal nerve were found in 56.5 per cent. Numbness of the face was the predominant manifestation occurring in sixty-three cases: it was mostly on the same side as the lesion, being contralateral in one and bilateral in another one. Tingling was present in five and burning in one.

Typical tic douloureux, with or without numbness, was present in sixteen cases, contrary to the experience of Cushing who did not find a single instance in his series. However, there are scattered reports in the literature confirming this finding, Dandy's (7, 8, 9) observations being outstanding. The pain was almost invariably unilateral; in only one instance it appeared opposite the side of the lesion and at operation in this case it was found that the tumor extended beneath the brain stem to the opposite side. Of these cases, eleven were admitted with the chief complaint of tic douloureux and with this diagnosis they were operated on. At operation through the unilateral cerebellar approach typical neurinomas were found at the angle. These cases

have been summarized by us in a previous communication (15) and in analyzing them we found that there was unilateral impairment of hearing in ten, which was not considered significant at the time, if the age group between 50 and 70 years was taken into consideration.

Subjective involvement of the motor root was elicited in two.

The average duration of trigeminal symptoms was 1.6 years and the time interval from the auditory symptoms was 3.3 years. The similarity of these figures with the ones found in headaches has already been remarked upon.

Symptoms referable to other cranial nerves: There was no subjective anosmia in any of the cases. Disturbances of vision will be discussed subsequently under symptoms produced by increased intracranial pressure. Subjective manifestations of VIth N. involvement were elicited in 17.7 per cent (25 cases) although objectively could be corroborated in only twenty-one cases. The average duration of diplopia was 1 year and the interval from the onset of acoustic disturbances was 4.3 years, therefore occurring rather late in the course of the illness and it never preceded the VIIIth N. symptoms.

The VIIth N. was subjectively affected in 15.8 per cent. In fifteen cases there was a history of facial weakness on the same side as the lesion. Ipsilateral spasms of the facial musculature occurred in four cases and typical gustatory fits were present also in four. The duration of facial symptoms was 5.2 years and the interval from the onset of auditory disturbances was 3 years. Facial manifestations always followed symptoms referable to the VIIIth N.

Dysphagia and dysarthria were present in 16.5 per cent, with a duration of 0.5 years and an interval from the onset of acoustic symptoms of 2.5 years. They followed auditory disturbances in every instance.

The XIth and XIIth Nerves were not affected subjectively.

Symptoms due to increased intracranial pressure: It is quite difficult to determine subjectively what constitute the symptoms of intracranial hypertension. Evidence has been presented (32) that the headaches in intracranial neoplasms are predominantly due to pressure of the tumor on neighboring structures and not due directly to increased intracranial pressure. Furthermore, as explained above, we think that acoustic tumor headaches, especially, are produced by pressure of the

growth on the sensory root of the trigeminal, neighboring meninges and vessels and possibly on the IXth N. In any event, headaches in this type of tumors come relatively early, sometimes representing the initial symptoms, and in many instances they were not associated with objective evidence of increased intracranial pressure. Blurring of vision might be considered a sign of increased pressure if associated with papilledema. Papilledema, however, might be present with no subjective evidence of diminution of vision, and, furthermore, increased intracranial pressure might exist without papilledema. Nausea and vomiting are symptoms of increased intracranial pressure but might also be associated with attacks of rotary vertigo, which were not uncommon in this series. Loss of sphincteric control and loss of consciousness are late manifestations, quite rare in this group of cases and therefore not good criteria. So it is obvious that an accurate estimate of the onset of symptoms of increased intracranial pressure is hardly possible. However, we have listed as symptoms of intracranial hypertension, blurring of vision associated with papilledema on examination and nausea and vomiting not accompanied by attacks of vertigo. There were 62 cases (47.2 per cent) fulfilling these criteria. However, there were thirty-six additional cases showing papilledema on admission without subjective evidence of blurring of vision or nausea and vomiting. The average duration of symptoms was 1.1 years and the time interval from acoustic manifestations was 4.5 years.

Tonic convulsions: We have carefully avoided the use of the term "cerebellar crises" as proposed by Jackson (19) and used by other authors. Most authorities are inclined to attribute them to lesions in the brain stem, most likely in the midbrain. There were only six cases (4.1 per cent) who gave a history of tonic convulsions, all of which occurred as very late manifestations. Four of these patients recovered after the operation and two died, showing, therefore, that when this stage is reached there is still chance for recovery, contrary to the views of others.

Objective Findings: State of consciousness: On admission most of these patients were alert and cooperative. One hundred and thirty-four (92.4 per cent) showed no disturbances of consciousness. Six (4.1 per cent) were drowsy and confused and five (3.5 per cent) were comatose.

Cranial Nerves: I. Anosmia has been described by others as a common feature in cases with increased intracranial pressure. In our series, however, it was quite rare and appeared in only three cases, being bilateral in all.

II. There was no impairment of visual acuity in ninety cases (68.1 per cent). Partial diminution of vision was elicited in forty-four cases (30.3 per cent), one of which showed complete loss of central vision. Total loss of vision was present in eleven (7.6 per cent). It is interesting to notice that in one case there was a history of visual hallucinations.

The visual fields were reported as normal in all the cases with normal vision. In patients with impaired vision the fields were reported as normal in half of them, the other half showing concentric constriction or bizarre changes.

Papilledema was a common, but not a constant finding, occurring in ninety-eight cases (66.5 per cent). It was described as slight in nineteen, moderate in fifty-one and massive in twenty-eight. Retinal hemorrhages accompanied choking of the discs in nineteen cases. They were not recorded as an isolated finding. Secondary optic atrophy was present in eighteen and macular degeneration in one.

III, IV and VI. Pupillary abnormalities were quite rare. One patient showed the ipsilateral pupil to be large and fixed, and another showed both pupils to be large and fixed without ptosis or limitation of the extraocular movements. Ptosis of the eyelids was not recorded in a single instance. Paralysis of the rectus externus was less frequent than we would expect in patients with intracranial neoplasms. It was present in twenty-one cases (14.5 per cent), being ipsilateral in twelve and bilateral in nine.

V. The Vth N. was, with the exception of the VIIIth, the cranial nerve most commonly affected; in fact, it was almost a constant finding in our series. One hundred and twenty-five cases (86.2 per cent) showed some degree of sensory impairment either on the face or corneae. This figure would increase if seven cases of tic douloureux without demonstrable sensory changes are included, boosting the total to one hundred and thirty-two cases (91 per cent). The corneal reflex was either diminished or absent in one hundred and twenty-two, in fourteen of which the involvement was bilateral. Complete or partial

sensory changes in the face or tongue were elicited in ninety-three, in three the involvement was bilateral, and in one in which the corneal involvement was ipsilateral, the sensory loss was contralateral. Corneal and facial sensibility were affected simultaneously in ninety-one cases.

Involvement of the motor root was quite rare, occurring in nine cases (6.2 per cent). The temporals, masseters and pterygoids were similarly affected. In only one case was the involvement bilateral. From this rare involvement of the motor branch we may derive that these neoplasms rarely grow as far forward as to impinge on the motor root of the Vth N.

VII. As the VIIth N. is in close association with the VIIIth N. one would expect a large incidence of facial paralysis in this kind of tumor. This is not the case, however. Facial paralysis was present in seventy cases (48.3 per cent). In fifty-three cases the paralysis was incomplete, affecting mostly the lower two-thirds of the face and in many instances was confused with the central type. Typical complete Bell's palsy was quite rare, occurring in seventeen cases. In one case the facial paralysis was contralateral to the lesion and in another there was bilateral involvement.

Tests for taste, unfortunately, were not done in most of our cases so they are not included in this study. It is interesting to note, however, that in four cases there was absence of taste in the anterior two-thirds of the tongue on the affected side, without apparent facial weakness. indicating that taste fibres might be affected at times much earlier than the motor fibres.

VIII. a. Auditory: Audiograms were taken in every patient except in one who was comatose on admission. Four other comatose patients had audiograms performed elsewhere previous to admission Complete or partial deafness was the most common sign in our series. The neurogenic type of deafness was confirmed in all affected. One hundred and thirty-nine cases (95.8 per cent) showed varying degrees of impairment of hearing: complete loss was found in one hundred and seven and partial in thirty-two. The impairment of hearing was almost invariably homolateral but in five cases it was bilateral. In cases showing partial involvement, the deafness was more marked for higher tones in the ear on the affected side (audiogram no. 1) as com-

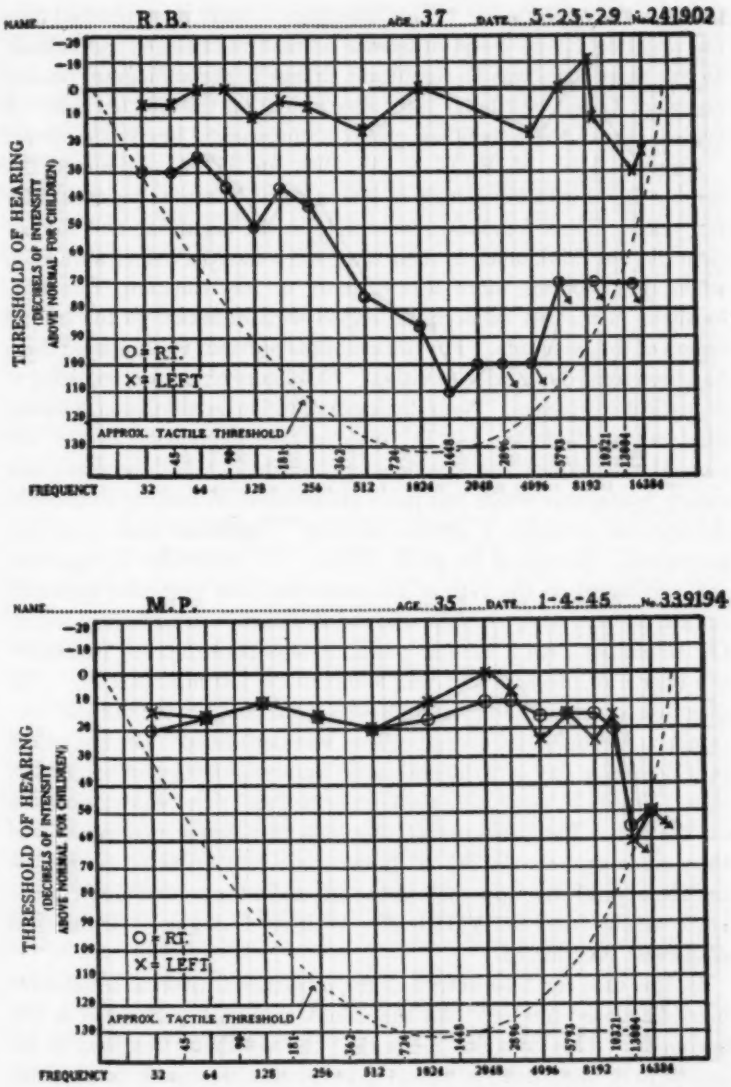
NAME R.B. AGE 37 DATE 5-25-29 No. 241902
THRESHOLD OF HEARING
(DECIBELS OF INTENSITY ABOVE NORMAL FOR CHILDREN)
O = RT.
X = LEFT
APPROX. TACTILE THRESHOLD
FREQUENCY 32 64 128 256 512 1024 2048 4096 8192 16384
NAME M.P. AGE 35 DATE 1-4-45 No. 339194
THRESHOLD OF HEARING
(DECIBELS OF INTENSITY ABOVE NORMAL FOR CHILDREN)
O = RT.
X = LEFT
APPROX. TACTILE THRESHOLD
FREQUENCY 32 64 128 256 512 1024 2048 4096 8192 16384

FIG. 1. Audiogram No. 1: Typical changes in a unilateral acoustic neurinoma. Audiogram No. 2: Acoustic neurinoma without hearing loss.

pared to the opposite ear. This difference is really more marked than the usual deficit we see in otherwise normal middle-aged individuals. In five cases there was no significant change in the audiogram (audiogram no. 2), but vestibular tests were absent on the affected side. A typical case of this anomalous group is summarized briefly as follows:

Case no. 136. M. P., W .F., 35, Hist. no. 33919. Admitted December 26, 44 with the history of intermittent bifrontal headaches for ten years. These headaches were mild in the beginning and the patient did not think much of them until a few months before admission when they became more severe, more or less constant, this time localized in the left suboccipital region with radiation to the frontal region of the same side. For three months previous to admission there had been some diminution of vision. No history of nausea, vomiting or acoustic disturbances. Neurologic examination on admission revealed bilateral papilledema, 2–3 D., questionable diminution of the left corneal reflex which was considered as normal by other observers, and rotary nystagmus which was more pronounced on looking to the left. Audiograms revealed a normal hearing. Vestibular tests were not performed. X-rays of the skull, normal. A ventricular air injection was performed on the 27th of December and the ventricles appeared normal in size with no shift and no evidence of obstructive lesion. On December 29th a lumbar puncture was performed to determine the degree of pressure and was found to be 450 mm. of c.s.f. The diagnosis of pseudotumor cerebri was made and on the 30th of December a subtemporal decompression was performed. On the fourth post-operative day a peripheral facial paralysis developed on the left side. Vestibular tests were then performed and there was no response on the left. The presumptive diagnosis of acoustic neurinoma was then made and on the 5th of January she was operated on by the unilateral cerebellar approach on the left and a tumor was found at the angle arising from the VIIIth N. Weight: 12.5 gms. Histological diagnosis: Neurinoma.

In this case the true nature of the intracranial process could have been diagnosed properly had the caloric test been performed in the beginning. This does not mean that the vestibular response is expected to be diminished or absent in every case of acoustic neurinomas because this is not true as we shall see later.

b. Vestibular: It is unfortunate that vestibular tests were not performed in all cases, as the diagnosis in most of them was so obvious that it did not appear necessary to subject the patient to additional diagnostic procedures. The cold caloric test was invariably used, and was performed in eighty-seven cases, seventy-seven (88.6 per cent) of which had impairment of the vestibular function on the same side of the lesion. In sixty-six the loss was total and in eleven partial. There was bilateral impairment of function in five and in one case the loss of function was contralateral to the side of the hearing deficit. In ten cases there was no loss of vestibular function but the hearing was definitely affected.

From the foregoing we must conclude that in neurinomas of the VIIIth N. we must expect involvement of both the cochlear and the vestibular branches, or at least one of them. This conclusion follows closely the results of Henschen and Cushing, diverging from the views of Bárány (2), and Olsen and Horrax (25) who claimed that we should invariably expect disturbances of the vestibular fibres. Others go even further in stating that these tumors, therefore, must originate primarily from the vestibular component. This last statement, we believe has been convincingly disproved by the work of Hardy and Crowe (17), who upon examining serial sections of temporal bones in two hundred and fifty autopsies found small acoustic tumors in six, the vestibular nerve being involved in four and the cochlear in two.

Other cranial nerves: Involvement of other cranial nerves was quite rare in our series. There was objective evidence of loss of sensation of the palate in ten cases. Ipsilateral paresis of the palate in thirteen and of the vocal cord in six. The XIth N. was even less often affected, occurring in only six cases. Atrophy of the tongue on the affected side was present in three instances.

Cerebellar signs: a. Nystagmus: Although there is still some debate about the source of nystagmus in acoustic tumors, it is the general concensus of opinion that its origin is definitely cerebellar. As pointed out by Ford (13), in nystagmus of cerebellar origin the eyes tend to seek a rest point situated from 10 to 30 degrees from the midline on the side contralateral to the lesion. On looking to the affected side, a coarse horizontal nystagmus is observed in which the slow phase is towards the rest point, but when the eyes are moved beyond the rest

point on the contralateral side, a finer, more rapid nystagmus is seen. The slow phase is again to the rest point. Ford states, furthermore, that this is a fixation nystagmus as is reduced or abolished when the eyes are covered and, therefore, may be distinguished from vestibular nystagmus by the fact that in the latter the slow phase is always toward the injured side and that it is increased by preventing fixation. Almost invariably our cases are described as showing these characteristics and this is the main reason for including nystagmus as a cerebellar sign. Although a common finding in this series, it is not constant. It was present in one hundred and five cases (72.4 per cent). The nystagmus was mainly of the coarse horizontal type (nine-three cases), rotary nystagmus being quite infrequent and occurring in only twelve cases. There was not a single instance of vertical nystagmus in our series.

b. Incoordination: Incoordination of cerebellar origin was as frequent an objective finding as the signs referable to the trigeminal nerve. It was found in one hundred and twenty-five cases (86.2 per cent). Incoordination usually affected the arm and leg on the affected side (sixty-nine cases), being bilateral in ten and affecting the homolateral arm alone in eleven. Both arms were involved alone in three and the homolateral leg was affected solitarily in one. The Romberg was positive in sixty one and the gait was definitely ataxic in one hundred and fourteen cases.

Pyramidal changes: They were relatively rare and usually occurred in well advanced cases where there was definite indication of pressure on the brain stem. They were present in twenty-seven cases (19.6 per cent), being contralateral to the lesion in nine, on the same side in eight and bilateral in ten.

Sensory changes: Sensory changes in the body and extremities were even less common and were present in only seven cases (4.8 per cent) being ipsilateral in four, contralateral in two and bilateral in one.

Roentgenological diagnosis: In every case where the diagnosis of an acoustic tumor was suspected, stereoscopic films of the base of the skull were taken in an attempt to visualize the porus acousticus, the Towne's position being rarely used. Unfortunately, we were able to find reports in only one hundred and fourteen cases. Of these, fifty-two (50 per cent) showed either enlargement or definite destruction of

the internal auditory orifice, seven showed just evidence of increased intracranial pressure as evidenced by destruction of the sella turcica

FIG. 2. X-ray of the base of the skull (M. R. Hist. No. 300471) showing marked destruction of the left porous acousticus from an acoustic neurinoma.

and increase in the convolutional markings. Forty-five cases did not show any abnormalities. (See Fig. 2.)

Air studies were rarely performed, being done in eight cases where the diagnosis was in doubt. Ventriculography was used in all of them. In five of these cases the ventricles were markedly dilated with definite evidence of a block at the aqueduct of Sylvius. In one case there was moderate dilatation of the ventricular system with no evidence of block or any other deformity. In two cases the ventriculograms were completely normal, showing small symmetrical ventricles with no evidence of obstruction. In none of these cases could the deformity of the ipsilateral occipital horn as described by Stone and Schulze (29) be visualized.

Lumbar Puncture: As lumbar punctures are definitely contraindicated in neoplasms of the posterior intracranial fossa for obvious reasons, they were not done in any except in one case, summarized elsewhere, in which the diagnosis was in doubt, the lumbar puncture being done with the sole purpose of measuring the pressure. As no fluid was withdrawn there was no report of its protein content, which has been found increased in many instances by others.

Ventricular Size: An approximate estimate of the size of the ventricles could be obtained in seventy-eight cases by tapping the occipital horns through posterior trephines as a preliminary step in the actual operative procedure. Forty-seven (60.3 per cent) showed marked dilatation of the ventricles. Moderate dilatation was present in thirteen (16.6 per cent). In one case the ventricles were slightly dilated. In five (6.4 per cent) they were found to be normal in size, and in twelve (15.4 per cent) they appeared quite small. No accurate estimate of the ventricular pressure was obtained, the only criterion being the objective degree of force displayed by the fluid on tapping the ventricles. Marked pressure was reported in sixty-two cases (82 per cent) and the pressure was considered normal in fourteen (18 per cent).

Weight of the tumor: It was not possible to obtain a true idea of the weight of the tumor because in about 75 per cent of the cases it was cystic and in many instances the cystic portion represented its major bulk. So the figures we are giving represent the solid contents of the tumor, including the capsule. Weights were recorded in one hundred and thirty-five cases, the smallest being 1 gm. and the largest, 70 gms., with an average of 18.9 gms. The weight of the tumor itself did not

have special bearing on the technical part of the operation as we find cases in which the larger tumors were easier to remove than the deep-seated smaller ones. However, it seems that the weight of the tumor has some relationship with the ultimate operative result, as we shall see later.

Operation and Operative Mortality: In discussing the operative technique and mortality in this series, we consider it worth while to make a brief review of the evolution of the modern operative technique as developed by Dandy. Cotterill (3) was perhaps the first to use the bilateral cerebellar exposure, but it was not until Cushing's introduction of the crossbow incision (4) that an adequate exposure of the cerebellum could be obtained. Krause's (20) improvement on the unilateral approach introduced by Woolsey (33), but previously used by others, although used with disastrous results in the removal of acoustic tumors, offered a valuable contribution to the ultimate development of Dandy's method. Up to Cushing's time, every attempt in removing these tumors was a depressing one and his contribution of intracapsular curettement (4) was the most important contribution up to that time. In his monograph on acoustic tumors he doubted whether these tumors could ever be totally enucleated with satisfactory results. Shortly afterwards, Dandy (6) published his preliminary report on the total extirpation through the bilateral cerebellar approach by painstaking dissection of the capsule after intracapsular evacuation of the contents. A few years late Dandy (10) modified the crossbow incision and introduced the transverse incision for bilateral exposure of the cerebellum which curved downward at both mastoid processes. This approach provided the same exposure and made the visualization of the angle easier because the nuchal muscles fall away from, rather than toward the line of vision and, furthermore, avoided the cerobrospinal fluid fistula which frequently occurred in the vertical part of the crossbow incision. Even with this improved procedure, however, he observed that the degree of trauma inflicted on the cerebellum by retraction was great and subsequently adopted the method of uncapping the cerebellum as first suggested by Frazier (14). The degree of exposure to the angle was therefore greater and the damage to the cerebellum less. In the early 30's (8) he found and extirpated a few tumors at the angle through the unilateral approach which was intended for sectioning

the sensory root of the Vth N. at the pons, as these patients complained of tic douloureux on admission. He observed that this procedure was feasible and entailed even less damage and post-operative edema to the cerebellum and brain stem.

From all these observations originated Dandy's classical unilateral procedure introduced in 1934 (11) and which is briefly summarized as follows: 1. same unilateral incision as used for Ménière's disease and tic; 2. bone rongeured as far laterally as possible without entry to the mastoid cells and anteriorly to the lateral sinus; 3. tapping of the posterior horn of a lateral ventricle through a previouly placed occipital trephine in the opposite side; 4. evacuation of fluid from the cisterna magna and spinal canal; 5. excision of the outer cap of the cerebellum; 6. intracapsular evacuation of the solid contents; and 7. careful, painstaking dissection and removal of the capsule. This procedure has been almost universally adopted and the general trend of most neurosurgical clinics at present is to remove these tumors in toto according to the method evolved by Dandy after so many years of toil.

By taking a quick glance at the following table on operative technique and mortality, we may see then why it was necessary to make the foregoing discussion as the operative mortality diminishes with the ultimate perfecting of the method of attack. As explained at the beginning of this presentation, almost all the neurinomas at the cerebellopontile recess were operated on by Dr. Dandy. One of the acoustic neurinomas was operated on by someone else and four were recurrences operated on originally at other clinics and therefore we consider it fair enough not to include these cases here, lowering the number of cases, consequently, to one hundred and forty.

In all of these cases the tumor was totally removed in one stage. As we see the over-all mortality for twenty years, including the different operative techniques, was of 22.1 per cent, which diminishes to 6.5 per cent when the unilateral approach with uncapping of the cerebellum and careful dissection of the capsule was done, representing a tremendous difference. This last figure represents the operative mortality during the last eight years (sixty-two cases), dropping to 2.4 per cent (1 fatality in forty-one cases) in the past five years. On the other hand, we may easily observe that the mortality rate is

tremendously high whenever the finger was used, no matter what the method of attack was. The operative mortality in these cases ranged from 40 to 100 per cent; therefore, this procedure cannot be too

TABLE 2

Operative Technique and Mortality in 140 Cases of Unilateral Acoustic Neurinomas—Total Extirpation

OPERATIVE TECHNIQUE	NO. CASES	LIVED	DIED	MORTALITY (%)
1. Bilateral Cerebellar				
A. No cerebellar cap				
a. Finger enucleation alone	5	2	3	60
b. Intracapsular + finger enucleation	4	1	3	75
c. Intracapsular + careful dissection	30	22	8	26.6
B. Cerebellar cap removed				
a. Finger enucleation alone	2	0	2	100
b. Intracapsular + finger enucleation	1	0	1	100
c. Intracapsular + careful dissection	12	11	1	8.3
2. Unilateral Cerebellar				
A. No cerebellar cap				
a. Finger enucleation				
b. Intracapsular + finger enucleation				
c. Intracapsular + careful dissection	13	10	3	23
B. Cerebellar cap				
a. Finger enucleation	1	0	1	100
b. Intracapsular + finger enucleation	10	6	4	40
c. Intracapsular + careful dissection	62	58	4	6.5
Total for twenty years	140	110	31	22.1

forcibly condemned, as no matter how careful we are, a certain amount of trauma is certain to be inflicted on the brain stem, and even a small amount may bring about disastrous consequences.

Analysis of Operative Deaths: a. Sex: Surprisingly enough, the mortality among men was greater than in women, in a proportion of

3:2, this proportion being greater if we consider that in the whole series females were affected much more frequently than males.

b. Age: The age did not have any bearing on the mortality rate and occurred between the ages of 23 and 65, with an average of 43.6 years, which approaches closely the average age on admission for the whole group.

c. Symptoms: There was no striking correlation between the symptomatology and the operative mortality, death occurring with equal frequency in patients with early and those with advanced symptoms. The average duration of symptoms in our fatalities, however, was slightly above the general average for the series, being 5 years, the shortest 3 months and the longest 18 years. On admission twenty-three patients were alert and cooperative, four comatose and three totally blind.

d. Weight of the tumor: The average weight of the solid contents of the tumor was 27.6 gms., the smallest 2 gms. and the largest 55 gms. The average weight is certainly much higher than in the whole group, which might tend to prove that the bigger the tumor, the greater the amount of pressure on neighboring structures, and the greater the degree of obstruction in the ventricular system, hence, making the final result of the operation more uncertain.

e. Time of death: The majority of these patients died within twenty-four to forty-eight hours after the operation, only one of them dying while on the operating table. These early deaths showed the usual signs of damage to the brain stem, as hyperthermia, tachycardia, laboured respirations, profound unconsciousness and tonic fits. The late fatalities occurred between the third and thirtieth post-operative day and were fewer in number, death being due usually to pneumonia or secondary infection.

f. Cause of death: Autopsy was performed in almost every instance but the cause of death, however, was not clear in three of them. For purpose of simplification we have divided the causes of death into four main groups as follows:

1. Direct trauma to the brain stem: Occurred in twelve cases. In practically all of them the finger was used in enucleating the tumor.

2. Meningitis: Four patients died of meningitis, death occurring quite late, an average of four weeks after the operation. In two of

them the mastoid cells were accidentally opened in rongeuring the bone. It should be mentioned that these deaths occurred before the era of the sulfones and the newer antibiotics.

3. Pulmonary: One patient died from pulmonary embolism and five from aspiration pneumonia, a direct consequence of paresis of the palate. Death from pulmonary causes occurred within the first two weeks post-operatively.

4. Vascular: These deaths were direct consequence of accidental ligation of vital arterial supply to the cerebellum and brain stem. In two cases the basilar artery was partially clipped, the patients dying six hours and three days, respectively, post-operatively. In two other cases the posterior inferior cerebellar artery was ligated, death occurring within the first forty-eight hours after operation. One patient died on the fourth post-operative day and at autopsy a large extradural hemorrhage was found at the operative site. Thrombosis of the left lateral sinus was found in another paitient who died on the third post-operative day; the cause of death in this case is quite debatable, however, as one may ligate a lateral sinus with no impairment of function.

End Results: Efforts have been made to contact every living patient, in itself a rather hazardous task. Up to the time of this communication follow-up studies have been possible in only seventy-six cases covering a period from one to eighteen years. There have been six deaths in these cases, four of which we feel are direct sequelae of the operation, giving a late case mortality of 5.2 per cent. In three of these patients post-mortem examination was performed: in two of them a marked hydrocephalus due to occlusion of the foramina of Luschka and Magendie was apparent, death occurring one and eight years, respectively, after the operation. One patient developed cerebrospinal fluid rhinorrhea shortly after the operation, followed later on by cerebrospinal fluid otorrhea and died one year later from meningitis: at autopsy a definite perforation was found on the petrous bone. In one patient no autopsy was performed, but in about six months after the operation she started to become confused and showed gradually signs of increased intracranial pressure. Her symptomatology was almost a replica of the other two patients who showed occlusion of the foramina at the base.

It is curious that in three of these patients there was evidence of internal non-communicating hydrocephalus produced by occlusion of the foramina of Luschka and Magendie. This might be explained simply on the basis of a basilar arachnoiditis due probably to a low-grade post-operative meningitis not virulent and severe enough to produce septic symptoms, although it also might be due to direct trauma, to the electrocautery or to slight post-operative bleeding with subsequent organization.

Recurrences: In the seventy-six cases which we were able to follow there was one recurrence, this occurring eleven years after the total extirpation of the tumor. This case represents the only instance in which a second operation was performed in this series.

Preservation of Facial Function: In total extirpation of acoustic neurinomas preservation of facial integrity is quite a difficult task, due to the close proximity and marked distortion of the VIIth N. by the neoplasm and its consequent injury during operation. The ultimate preservation of the VIIth N. we consider as a vital step in the removal of these tumors due to the future disability entailed by a disfigured face when the patient tries to resume his previous occupation. Besides the cosmetic reasons we should also bear in mind the possibility of corneal ulceration in an anaesthetic eye with a Bell's palsy. In this series, unfortunately, the facial nerve was preserved in only nine cases.

To obviate the facial disfigurement spino-facial anastomosis was performed in practically all the cases with post-operative facial paralysis. Good functioning of the anastomosis was obtained in 95 per cent of the cases. This return of function, however, is quite relative, as in most cases the facial movements have to be controlled by movements of the shoulder, a task that requires plenty of practice and the cooperation of an intelligent patient Even then, the facial movements obtained are quite grotesque, coming in the form of a mass reflex of the whole musculature of one side of the face.

In twenty-one cases the spino-facial anastomosis has been combined with a plastic operation in the face by means of transplants of fascia lata strips insuring a satisfactory anchorage between the temporal fascia and the periorbital and perioral muscles at the nasolabial fold. The technique has been described by Hanrahan and Dandy (16)

several years ago. This corrective measure, we believe, affords the best cosmetic results. The nerve anastomosis is necessary to preserve muscle tone and the fascial transplant is important in correcting the flatness and asymmetry of the face at rest, not corrected by anastomosis alone. (See Fig. 3.)

The ultimate goal should be, therefore, the total preservation of the facial nerve at operation. This has been advocated by Olivecrona (24)

FIG. 3. I. S. Hist. No. 255497 showing the result of a combination of spinofacial anastomosis and plastic operation on the face. Left: Face at rest. Right: Movement of the left face controlled by raising the shoulder. (Courtesy of Hanrahan, E. M., and Dandy, W. E.: A procedure to correct facial paralysis. J. A. M. A., April 8, 1944, **124:** 1051–1053)

who was able to preserve the anatomical continuity of the nerve in 65.2 per cent of his cases by careful electrical stimulation of the undersurface of the tumor during dissection of its capsule. If this entails, however, leaving part of the tumor adherent to the nerve we should not hesitate to sacrifice the nerve as a recurrence would appear inevitable.

Comments: In summarizing, we have shown that the unilateral acoustic neurinomas, without evidence of neurofibromatosis elsewhere in the body, represent the most common type of neurinoma at the cerebellopontile recess, and they occur predominantly in females.

The average age at the onset of symptoms was 39.6 years, with an average duration of symptoms of 4.5 years.

Only 31 per cent of the cases followed the chronological order postulated by Cushing; in 69 per cent this order was changed in different fashion. This great variation may be easily explained by variation in the degree and direction of the growth and by individual anatomical differences at the angle.

In the greatest number of instances there was subjective and objective evidence of involvement of the VIIIth and Vth nerves, as well as the cerebellar pathways. The VIIIth N. was involved in every case, either by affection of both components or by solitary involvement of either the cochlear or vestibular branches. In certain instances only the VIIIth N. was affected alone, the patients presenting on admission Ménière's syndrome, which although uncommon with tumors at the angle, does occur and therefore is worthwhile to remember in the differential diagnosis of this disease.

Tic douloureux was the only complaint in many instances, but in this series was always accompanied by some loss of hearing, which one is liable to neglect if we consider the late age in which this symptomatology was present in our cases. Audiometer and vestibular tests are, therefore, in order in every patient with tic douloureux. These tests, however, are of no value in other kinds of tumors at the angle producing tic douloureux; e.g., pearly body tumors, as has already been shown in another communication, due to the fact that the VIIIth N. is not primarily affected.

The diagnosis may be made clinically in most of the cases. X-ray evidence of destruction of the porus acoustics was present in only 50 per cent of the cases and when absent was not, therefore, absolute proof against a positive diagnosis. Ventriculography was rarely indicated, and when done showed either symmetrical dilatation of the ventricular system, a block at the aqueduct or perfectly normal ventricles.

The best method of operative attack of these tumors is by the procedure devised by Dandy. Enucleation of the tumor with the finger cannot be condemned too strongly because of the trauma inflicted on the brain stem. The mortality is usually very low if careful and painstaking dissection of the capsule is performed.

Early operative mortalities are predominantly due to one of four causes, namely: 1. trauma to brain stem, 2. vascular occlusion of vital arteries in the posterior fossa or post-operative bleeding, 3. meningitis as direct sequela to opening of the mastoid cells, and 4. aspiration pneumonia. Late mortality, on the other hand, might occur years after the operation due to cicatricial closure of the foramina of Magendie and Luschka, an internal non-communicating hydrocephalus being the end result.

The ultimate goal of any operative procedure should be the preservation of the facial nerve. When this is not possible, a spino-facial anastomosis combined with a plastic operation on the face should be the method of choice.

UNILATERAL ACOUSTIC NEURINOMAS AND VON RECKLINGHAUSEN'S DISEASE

The uncommon coexistence of unilateral acoustic neurinomas and peripheral von Recklinghausen's disease has already been mentioned. In the whole group we were able to find only three cases of unilateral tumors with evidence of peripheral neurofibromatosis (1.8 per cent).

One male and two females were affected. The average age on admission was much shorter than in the previous group, being 24.3 years, 22 the youngest and 26 the oldest. In one case the peripheral neurofibromas were noticed 1 year before the onset of intracranial disturbances, in another one the cranial nerve symptoms preceded the appearance of the peripheral tumors by two years and in the third case the peripheral lesions were noticed on admission and no definite history could be obtained about the time of their appearance. The average age at onset of intracranial manifestations was 14.3 years, the earliest being 9 and the oldest 20 years. The duration of symptoms was 10 years, and, therefore, twice as long as in the preceding group. There was no history of trauma or infection.

Symptomatology: In none of these cases could we find a constant chronology of symptoms. Auditory, cerebellar and trigeminal manifestations represented the initial symptom in each respective case. In all cases, however, the outstanding symptoms were auditory and cerebellar.

The auditory manifestations were characterized by gradual diminu-

tion of hearing in two, and sudden unilateral deafness in one. There was bilateral impairment of hearing in one in which the possibility of bilateral lesions was suspected but never corroborated as the unilateral approach was used at operation. Tinnitus was present in two, coming in one of them simultaneouly with the impairment of hearing and in the other one it followed the auditory deficit. There were no vestibular dsiturbances with the possible exception of one patient who complained of nocturnal loss of balance.

Cerebellar disturbances were prominant in the three cases and always occurred on the same side as the lesion.

Subjective disturbances to the Vth N. were present in two cases, in one of which they preceded the auditory manifestations by nine years and one wonders whether this case represented primarily a tumor arising from the Vth N. or not. In the other case it followed the hearing loss by six months. Not a single patient complained of headache.

Facial weakness was noticed subjectively by one patient, occurring six months after the onset of auditory manifestations. There were no subjective manifestations referable to other cranial nerves.

Symptoms referable to the spinal cord and characterized by spastic weakness of the extremeties with typical mass withdrawal was present in one case, indicating the multiplicity of lesions in the central nervous system. They occurred rather late and followed the auditory manifestations by 3.5 years.

Signs: Subcutaneous nodules were prominent in the scalp, upper extremities and trunk. All patients were well-oriented and alert on admission.

Papilledema was present in one. Involvement of the IIIrd and VIth nerves was present in one case, the involvement occurring in the same side as the lesion. All patients showed a diminished corneal reflex and impaired sensation of the face on the same side as the lesion. In one case there was involvement of the motor branch of the Vth N. Facial paralysis of the peripheral type, incomplete, was present in two.

The neurogenic type of deafness was corroborated in all, being bilateral in one. It was total in two and partial in one. Caloric tests were performed in only one case which showed bilateral loss of vestibular response.

Cerebellar signs could be elicited in only two cases, in spite of the fact that all gave a history of subjective involvement of the cerebellar pathways. Nystagmus was not a constant finding and was found in only one case. It was of the horizontal type. Involvement of the IXth, Xth, XIth and XIIth nerves was present in one case, which showed in addition involvement of the spinal cord, as evidenced by motor weakness of all extremeties with bilateral pyramidal signs and a sensory level to T4.

Roentgenological diagnosis: X-rays were taken in all cases. In two of them there was marked destruction of the porus acousticus and in one they were negative. Air studies were not performed.

Ventricular Size: Ventricular estimation was performed in two cases, one of which showed marked dilatation of the ventricles and the pressure was said to be greatly increased. In the other one the ventricular pressure was normal and the ventricles were relatively small.

Operation, operative mortality and end results: As the predominance of symptoms and signs was present on the right side in all cases the unilateral cerebellar approach was performed in all. The cerebellar cap was resected but the curettement of the contents was extremely difficult, due to the marked hardness of the tumor. Erosion of the acoustic foramen was corroborated in all. In only one cases the tumor seemed to arise from the Vth N., this case being the one in which subjective disturbances of the sensory branch of the Vth N. were present nine years before the onset of auditory manifestations. One patient died seven years later with signs of marked involvement of the spinal cord, with no indication of intracranial recurrence. Another patient died on the fourth post-operative day with signs and symptoms pointing to trauma of the brain stem. The other patient is living and well at the end of six years.

Comments: Only three cases of unilateral acoustic neurinomas associated with peripheral neurofibromatosis were found in this series. The age at onset of intracranial disturbances was far below the age of patients with solitary neurinomas, e.g., 14.3 years, and the duration of symptoms was quite prolonged (ten years). There was no specific chronologic order of symptoms but the auditory, trigeminal and cerebellar manifestations were quite predominant and the first two were objectively constant. Only one patient showed involvement of the

spinal cord. The operation was quite difficult in all cases, due to the extreme hardness of the tumors which would make their curettement a very difficult procedure. The final outcome in these cases is not a happy one, as they have been reported to be associated with multiple meningiomas or other neurinomas within the intracranial chamber or along the spinal canal.

BILATERAL ACOUSTIC NEURINOMAS

Six cases (3.7 per cent) of bilateral tumors of the nervus acousticus were found in our series, five of which were verified either at operation or autopsy, and in the other one they were suspected because of the bilateral signs and early age of the patient. In this last case the opposite side was not explored at operation and the patient died a few hours later. Unfortunately, no autopsy was performed.

Etiology: It is thought that these tumors when bilateral are congenital, because of the relatively young age of the patients and their common hereditary transmission according to the laws of Mendel. In two of these patients, who were sisters, there was a history of bilateral acoustic neurinomas in the maternal side of the family in approximately thirty-five members since the eighteenth century, the persons so affected having complained of bilateral deafness, and having died relatively young, approximately five years after the onset of symptoms.

Their relationship to von Recklinghausen's disease seems more obvious than in the case of unilateral neurinomas. Three cases (50 per cent) showed evidence of peripheral involvement elsewhere in the body.

Incidence: Males and females were equally affected. The average age on admission was 23 years, the youngest 14 and the oldest 33. The average age at onset of symptoms was 17.8 years, the youngest 9 and the oldest 29. As pointed out earlier, these figures resemble very closely those found in the unilateral tumors with evidence of neurofibromas elsewhere in the body. The duration of symptoms, however, was much shorter, being 5 years.

Subjective manifestations: The initial symptom in four was that of increasing deafness, while in the other two the manifestations were represented by subjective evidence of increased intracranial pressure and involvement of the cerebellar pathways, respectively.

All patients but one gave a history of impairment of hearing bilaterally, one ear being affected first in three and both ears simultaneously in two. The other patient gave a history of impairment of hearing on one side, but the audiogram on admission showed also moderate diminution of hearing on the opposite side. Tinnitus was present in one case; it was unilateral and apperared three years after the onset of other auditory symptoms. History of vertigo was obtained in two, in one of which it was just a subjective sensation of dizziness and in the other one of true rotary type. It appeared one month and two years, respectively, after the onset of deafness.

Cerebellar symptoms were present in every case. They followed auditory and labyrinthine symptoms but in one case preceded them by two months. The usual complaint was staggering on walking.

Headache was not a common symptom, being present in only one case. This patient complained of bifrontal type of pain without history of suboccipital discomfort. There was no subjective evidence of involvement of the Vth N., although objective findings were present in three.

Hoarseness and dysphagia were present in one case, appearing three years after the onset of symptoms. Subjective manifestations of increased intracranial pressure were present in four, in one of which it was the apparent initial symptom, being a late manifestation in the other three.

Objective findings: There was objective bilateral impairment of hearing in all cases (Fig. 4). Total bilateral deafness was found in four and unilateral deafness with moderate degree of hearing impairment on the opposite side was found in two. The neurogenic type of deafness was corroborated in all cases. Vestibular tests were performed in five. They showed preservation of vestibular response bilaterally in one case, diminished bilateral response in three, and absent vestibular response on only one side in another.

Cerebellar signs such as ataxia of the extremeties and staggering gait were present in all cases. They were bilateral in four and unilateral in two. Horizontal nystagmus was elicited in five with equal amplitude on looking to either side.

Sensory changes on the face were present in four cases with accompanying diminution of the corneal reflex. These signs were present bilaterally in two of the cases.

Facial weakness was elicited in five cases. It was unilateral in three and bilateral in two. As it is the case in most of the neurinomas of the posterior fossa, this peripheral weakness was incomplete in the affected cases. The IXth and Xth N. were involved in only one case, the affection being bilateral. There was no involvement of other cranial nerves.

Pyramidal signs were present in one case, the involvement being bilateral. There were no sensory changes.

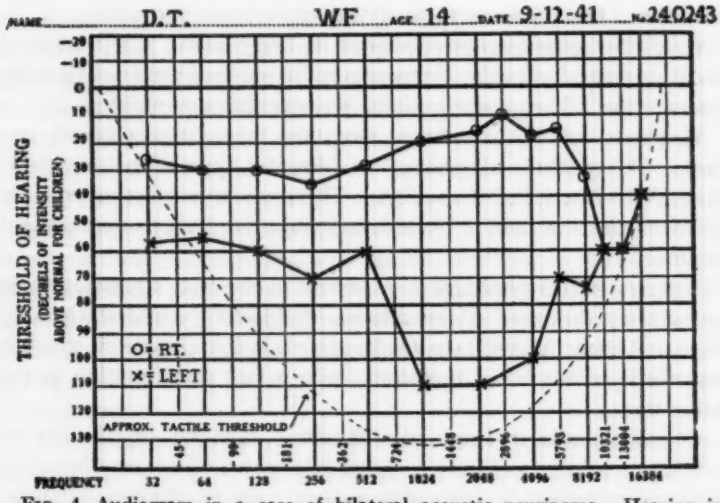
NAME D.T. W.F. AGE 14 DATE 9-12-41 No. 240243
THRESHOLD OF HEARING
(DECIBELS OF INTENSITY ABOVE NORMAL FOR CHILDREN)
O = RT.
X = LEFT
APPROX. TACTILE THRESHOLD
FREQUENCY 32 64 128 256 512 1024 2048 4096 8192 16384

FIG. 4. Audiogram in a case of bilateral acoustic neurinoma. Hearing is bilaterally diminished, more so on the left.

X-rays: Roentgenologic examination of the skull was reported in four cases. In one there was evidence of erosion of the porus acousticus on both sides (Fig. 5). Another one showed an unilateral erosion and the other two showed no apparent changes. There were no air studies performed in any of the cases.

Ventricular size: Considerable hydrocephalus was found in two cases, moderate enlargement in one and small ventricles in another one. No report of the size of the ventricles could be found in the other two cases.

Operation, operative mortality and end results: The operative approach is rather difficult in these tumors, as the operating space is greatly

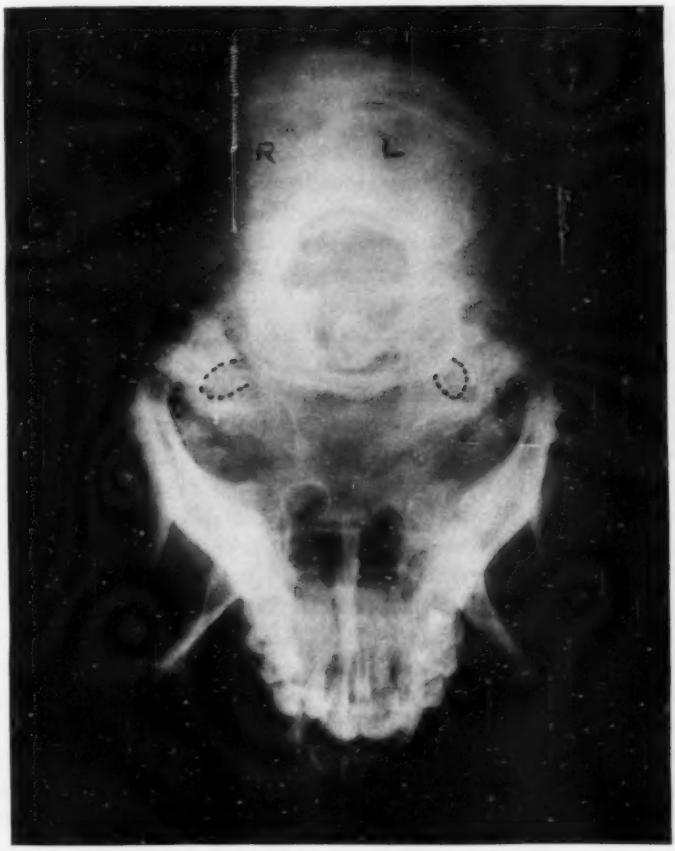

FIG. 5. X-ray of the base of the skull (G. W. Hist. No. 335824) in a case with bilateral acoustic neurinomas erosion at both acoustic meati.

reduced due to the presence of tumor on both sides and the subsequent edema of the cerebellum and brain stem upon attempting removal of these tumors. Consequently the mortality is high as is shown in the following brief operative summary of these cases.

Case No. 1: Unilateral approach without resection of the cerebellar cap. Enucleation with the finger. Suspected of having a bilateral tumor due to bilateral symptoms, but only one side was explored, from which a large tumor was removed. Patient died seven years later at another hospital from bronchopneumonia and gangrene of the lungs. At autopsy, in addition to the pulmonary pathology, an acoustic neurinoma was found on the opposite side.

Case No. 2: Unilateral approach without cerebellar cap. Enucleation with the finger. Bilateral tumors were not suspected in spite of the bilateral impairment of hearing. Tumor on one side completely removed. Returned four years later with clear-cut signs pointing to a lesion in the opposite side with complete deafness. Operation showed a large acoustic tumor in the opposite side which was removed in toto. Uneventful recover, except for bilateral facial paralysis and paresis of vocal cords.

Case No. 3: Bilateral cerebellar with bilateral section of cerebellar cap. Enucleation with the finger. Bilateral removal of the tumor in one stage. Death in 48 hours. Autopsy revealed diffuse softening of the brain stem.

Case No. 4: Unilateral cerebellar with removal of cerebellar cap, intracapsular curettement and careful dissection of the capsule. Tumor successfully removed in one side. As the patient gave familial history of bilateral tumors (patient is sister of Case No. 3) and had bilateral signs it was recommended that she report in six weeks for a second operation. Patient did not report until six months later, with total blindness. Operation of the other side was not recommended.

Case No. 5: Bilateral cerebellar, resection of the cerebellar cap. Enucleation with the finger. Tumor completely removed in one side. It was visualized in the other side but not removed as a second operation was contemplated. Patient died on the third post-operative day. No autopsy.

Case No. 6: Bilateral cerebellar. Cerebellar cap not resected. Enucleation with the finger. Tumor totally removed in one side. Although the patient had bilateral signs it was not considered advisable to explore the opposite side. Patient died a few hours later. No autopsy.

Comments: From this summary of cases with bilateral neurinomas one may conclude that these tumors do not represent diagnostic problems. In the first place they occur in young individuals, the average age at onset being 17.8 years. The duration of symptoms is more prolonged than in the solitary acoustic neurinomas and much shorter than in acoustic neurinomas with peripheral neurofibromatosis. In half of these tumors there is evidence of peripheral neurofibromas and there seems to be a very definite familial predisposition. The symptomatology is typically characterized by bilateral diminution of hearing which may be accompanied by other bilateral signs.

The operative attack on these tumors presents a rather difficult problem due to the reduced operating space and the subsequent greater edema of the brain stem and cerebellum. Therefore, the operative mortality is high. The best method of approach, we believe, is the bilateral cerebellar with extirpation of the tumor in two stages. As in the solitary acoustic neurinomas, the enucleation of the tumor should be done in a painstaking manner, as the trauma inflicted on the brain stem would be much greater when the finger is used in their removal.

Case No. 3: G. W., W. F., 24, Hist. No. 335824. Admitted on the 27th of October 1944, with the chief complaint of progressive deafness for five years. The family history revealed that ever since the eighteenth century, the Campbell family, maternal side, had suffered from bilateral deafness and premature death. There did not seem to be any predilection for sex; the onset of auditory disturbances always started between the ages of twenty and thirty years, every member so affected dying five years after the onset of symptoms. The present patient knew of thirty-five of her maternal ancestors who died in this manner. Of her immediate family she remembered that her mother died at the age of 34, an uncle at 32 and her grandfather at 30. A sister of thirty-two years (Case No. 4) had been suffering from bilateral deafness and ataxia. The onset of symptoms of this patient started five years previously and was characterized by progressive diminution of hearing on the right. Exactly one year after the onset she suddenly found that she was completely deaf in both ears and for the first time clumsiness in the arms and slight staggering on walking was noticed. These symptoms, however, remained stationary until one year before

admission when she started to complain of dysarthria and dysphagia along with fleeting and sudden episodes of blindness on stooping. Five months before admission she noticed some weakness of the left side of the face, which also appeared on the right side shortly afterwards. Physical examination on admission was essentially negative, except for scattered "café au lait" spots on the trunk and abdomen. Neurologic examination revealed marked diminution of visual acuity bilaterally. 6 D. papilledema in both fundi. Bilateral diminution of the corneal reflexes with hypaesthesia and hypalgesia in both sides of the face. Bilateral facial weakness, peripheral, incomplete. Horizontal nystagmus with equal amplitude on looking to either side. Bilateral total deafness. Absent vestibular response on the right and markedly diminished on the left. Absent pharyngeal reflexes on both sides. Marked dysmetria and asynergia of all extremities. Staggering gait. Positive Romberg. Moderate spasticity of all extremeties with hyperactive deep reflexes, bilateral Hoffman's and Babinski. X-rays of the skull: marked dilatation of both internal acoustic meati. Operation (Oct. 28–44): Bilateral cerebellar approach. Removal of cerebellar cap. Typical neurinomas found at each angle. Curettement of the tumors extremely difficult due to pronounced hardness of contents. Enucleation of both tumors with the finger. Weight: Right: 16.6 gms.; left: 10.7 gms. Histological examination: Neurinoma. Postoperatively the patient never regained consciousness. There was marked hyperthermia, rapid, thready pulse and labored respirations. Died in forty-eight hours. Autopsy revealed diffuse softening of the pons and medulla.

NEURINOMAS OF THE VTH NERVE

Neurinomas of other cranial nerves in the posterior fossa are so rare that little attention has been given to them in the classical discussions of this kind of tumors. There are several investigators who may even question the origin of these neoplasms from any other cranial nerve but the VIIIth. In our series of one hundred and sixty cases we have found three tumors (1.8 per cent) arising from the Vth N., two (1.2 per cent) from the Xth and one (0.6 per cent) from the XIth.

The criteria we have used for classifying tumors arising from the Vth N. were that the initial symptoms were referable to the trigeminal

nerve and that this nerve was found at operation to be more affected than the VIIIth N., and we might also add that in some instance there may be a return of auditory and labyrinthine function after the operation. This last criterion, however, is not very convincing as there are several reports in the literature where return of auditory and vestibular functions were noted after operation in typical acoustic neurinomas.

Two females and one male were affected. The lesion was found on the left side in all three cases. The average age at admission was 57 years and the age at onset, 47 years, with an average duration of symptoms of ten years. There was no history of trauma or infection and there was no evidence of peripheral neurofibromatosis.

Symptoms: In these three cases, the initial and predominant symptoms were those referable to the Vth N. and preceded the auditory and labyrinthine disturbances by an average of 4.5 years, the longest 11 years and the shortest 6 months. The chief complaint on admission was that of tic douloureux on the same side in two cases, and subjective numbness of one side of the face in the other. Auditory or labyrinthine manifestations were present in all. Unilateral and gradual diminution of hearing was present in all. History of unilateral tinnitus was present in two, occurring simultaneously with the hearing loss in one and preceding it in the other. Vertigo was likewise present in two and always preceded the loss of hearing. Subjective cerebellar disturbances were elicited in one case, being unilateral and appearing simultaneously with the auditory and labyrinthine manifestations. There were no subjective disturbances of other cranial nerves, nor any pyramidal or sensory changes.

Signs: All patients were alert and cooperative on admission. There were no disturbances of vision and mild papilledema was present in one case. Objective disturbances of the Vth N. were present in two and were characterized by a diminished corneal reflex and hypalgesia on the affected side of the face. The only case that did not show any sensory changes was the one in which the predominant symptom was that of tic douloureux. The VIIIth N. was affected in one case, the paralysis being an incomplete peripheral. There was varying degree of neurogenic deafness in two cases, which was unilateral but no caloric tests were performed in them. Hearing was normal in one

patient who showed complete abolition of the vestibular response. Cerebellar ataxia on the same side as the lesion was present in one case. There were no other neurologic signs.

X-rays were taken in two of them and erosion at the porus acousticus was reported in both.

No data were given about the ventricular size in two cases. The ventricles were moderately dilated in one with marked increase in pressure.

Operation, operative mortality and end results: All these patients were explored, two of them by the unilateral approach and one through a bilateral exploration. The cerebellar cap was resected in two and curettement of the contents plus careful dissection of the capsule was carried out in all. There were no mortalities. All of them showed a complete Vth, VIIth and VIIIth nerve paralysis. However, one patient showed marked return of hearing and complete return of vestibular function two months after the operation. We have been unable to carry out sufficient follow-up studies in these three cases.

Comments: Although neurinomas of the Vth nerve at the cerebellopontile recess are very rare they do occur, three such cases being reported in this series. The age at onset of symptoms was 47 years, much later than in the acoustic neurinomas, with a duration of approximately ten years, which approaches quite closely the duration of symptoms of unilateral tumors of the VIIIth N. with peripheral neurofibromatosis. Upon admission to the hospital these cases were clinically undistinguishable from the unilateral acoustic neurinomas and the only important differential diagnostic point lies in the fact that trigeminal symptoms preceded auditory and labyrinthine disturbances by an average of 4.5 years.

In two of these patients the initial and predominant complaint was that of tic douloureux and this point stresses again the important relationship of tumors at the cerebellopontile recess in the causation of trigeminal neuralgia. At operation the Vth N. was usually more affected than the VIIIth N., and in one instance there was marked return of cochlear and vestibular functions. This return of function makes one wonder if many of the cases reported in the literature in which such return occurred in supposedly acoustic neurinomas, did not actually represent neurinomas arising primarily from the Vth N.

Case No. 2: J. F., W. M., 67, Hist. No. 255352. Admitted on the 30th of March 1942, with the chief complaint of typical tic douloureux, left, for 15 years. The onset was insidious and characterized by intermittent attacks of paroxysmal lancinating pain on the left side of the face, affecting the distribution of the second and third branches. The pain was infrequent at first but in a few years it became more pronounced and would come at more frequent intervals. From three to four years previous to admission the patient started to complain of gradual and progressive diminution of hearing on the left without tinnitus or dizziness. Six months before admission, slight diminution of hearing on the right. Neurologic examination on admission showed 50 per cent hearing loss on the left and a normal hearing on the right; this partial deafness was found to be neurogenic in type. No caloric tests were performed. There were no other positive neurologic signs. X-rays showed suggestive erosion of the porus acousticus. Operation: March 31, 42: Unilateral cerebellar approach, left. Cerebellar cap was not resected. Deep in the angle and extending between the Vth and VIIIth N. there was a grayish tumor, the size of a hazel-nut, which was completely removed. Porus acusticus was not involved. It was difficult to ascertain from operative report whether the Vth or the VIIIth Nerve was predominantly involved. The Vth N. was sectioned, nevertheless. Weight of the tumor not reported. Histological report: Neurinoma.

NEURINOMAS OF THE XTH NERVE

Two such cases were found in this series and they must be, therefore, extremely rare. One male and one female were affected. On admission the ages were 36 and 54 years, respectively, the age at onset, 29 and 53 years, and the duration of the symptoms, 1 and 7 years. The left side was involved in both cases and there was no history of trauma or infection elicited.

Symptoms: The predominant symptom in both cases was hoarseness which represented the initial complaint in one. Left suboccipital headaches were the initial manifestations in the other case, but horaseness appeared six months after the onset of the headaches. Disturbances referable to the VIIIth N. were present in one case, appearing two years after the onset of hoarseness. There was no

subjective involvement of the Vth N. In one there was a history of facial weakness which appeared 5.5 years after the onset of hoarseness. Dysphagia appeared 6.5 years later in one and four months later in the other one. Cerebellar manifestations were present in only one case, on the same side as the lesion. Vision was impaired in one. Occipital headaches were present in both; in one, as mentioned above, they represented the initial symptom and in the other they appeared six years afterward. There was no subjective pyramidal or sensory involvement.

Signs: Both patients were alert and cooperative on admission. Only one showed diminution of visual acuity and bilateral papilledema. This patient also showed absent corneal reflex, unilateral analgesia of the face, complete peripheral facial paralysis, complete ipsilateral nerve deafness, paralysis of the ipsilateral vocal cord and palate, weakness of ipsilateral trapezius, sternomastoid and of the same side of the tongue, with cerebellar signs on the side of the lesion. In the other patient (summarized below) there was unilateral paralysis of the vocal cord and palate on the same side as the lesion, these being the only positive neurologic signs on admission.

X-Rays: In only one patient, who showed widespread involvement of the cranial nerves, were we able to corroborate erosion of the porus acousticus.

No data are given as to the ventricular size in any of these cases.

Operation, operative mortality and end result: The unilateral cerebellar approach was performed in both cases with resection of the cerebellar cap, curettement of the contents and complete removal of the capsule. In the case showing only involvement of the Xth N., a small tumor was found arising from the anterior filaments of the Xth N. The other case with marked involvement of the cranial nerves had a rather large tumor weighing 30 gms. The IXth and Xth nerves were lost within the neoplastic mass and the other cranial nerves anterior to it were tremendously pushed forward by the anterior projection of the neoplasm. Both patients were discharged from the hospital in an improved condition. Three and six years, repectively, after discharge, they are vastly improved and have resumed their former occupations.

Comments: Neurinomas of the Xth N. are extremely rare. They occurred in two cases. The age at onset of symptoms was 29 and 53

years, respectively, the duration varying between 1 and 7 years. These neurinomas are easy to diagnose as the predominant and initial symptom is that of hoarseness. At times, however, they might represent diagnostic problems, as in one of our cases in which the only symptom present was hoarseness. If hoarseness is associated with ipsilateral paralysis of the vocal cords a tumor of the Xth N. is a likely possibility.

Case No. 1. I. B., W. F., 54, Hist. No. 237504. Admitted July 29, 1941, with a history of gradually increasing headaches in the left occipital and temporal regions at times of radiating to the lateral aspect of the left side of the neck for one year. These headaches were worse on lying down. One month after onset of headaches she started to complain of intermittent attacks of hoarseness which gradually increased in frequency so that for eight months prior to admission it was constant. For eight months she had some difficulty in swallowing, which had become worse a few weeks before admission. Since onset of symptoms she thought there was also some impairment of taste in the left side of her tongue. On admission the physical examination was negative. The neurologic examination revealed questionable loss of taste in the left side of the tongue, paralysis of the left palate and left vocal cord. There was no hearing loss and no apparent sensory loss in the posterior pharynx. Operation: August 1, 41. Unilateral cerebellar approach, left. The cerebellar cap was not resected. A reddish mass was found in the posterior aspect of the recess, arising from the anterior aspect of the Xth N. The mass was the size of a hickory nut and was removed in toto. Weight: 2 gms. Histological examination: Neurinoma. Patient had a smooth convalescence except for marked dysphagia and hoarseness for a few months. When contacted six years later she was feeling fine and was engaged in her former occupation.

NEURINOMAS OF THE XITH NERVE

Only one case in this group. It was classified under this heading because the initial symptom was that of involvement of the XIth N. in the absence of hearing involvement. In contradistinction with the last two cases there was definite evidence of peripheral neurofibromatosis.

Case No. 1: C. W., W. M., 68, Hist. No. 305730. Admitted on the

27th of October, 1943, with the history that for many years he had noticed a growth on the right thigh. This growth had been removed six years previous to the present admission and proved to be a neurofibroma. For seven years he had also noticed a painless swelling, which did not appear to increase in size, behind the right ear. About 4.5 years before admission he started to complain of stiffness of the left arm with gradual atrophy of the left shoulder girdle. Because of these complaints he was seen six months later at another clinic where the diagnosis of brain tumor was made and the patient was given deep x-ray therapy without relief. About this time he started to notice pain behind the left ear on coughing and sneezing, and some dysphagia. These symptoms increased in the next few years. One year previous to admission he started to complain of hoarseness and incontinence of urine and feces. There were no hearing difficulties and no history of vertigo. On admission the physical examination revealed generalized arteriosclerosis and a small, soft, tender mass over the right mastoid which appeared to be a neurofibroma. The neurologic examination revealed a horizontal nystagmus on looking toward the right, paralysis of the left vocal cord, absent left palatal and pharyngeal reflexes, atrophy of left stenomastoid and trapezius, atrophy of the left side of the tongue, asynergia and dysmetria on the left arm and leg, a positive Romberg and a questionable hypesthesia of the left side of the body. Operation: Oct. 30, 43. Unilateral cerebellar approach, left. Resection of the cerebellar cap. A rather large tumor was found involving particularly the floor of the posterior fossa and extending into the spinal canal through the foramen magnum. The VIIIth N. was not involved. The tumor was totally removed. Weight: 25.8 gms. Histological diagnosis: Neurinoma. Patient had a smooth and rapid convalescence. No hearing loss was detected after the operation. When seen a year later the patient was much improved.

Comments: Neurinomas of the XIth N. are very uncommon and when found they are usually accompanied by evidence of neurofibromatosis elsewhere in the body. In our case it apparently started in the spinal canal forcing its way into the posterior fossa via the foramen magnum. As in this case, neurinomas of this type do not represent diagnostic problems.

PATHOLOGICAL CONSIDERATIONS

Voluminous literature has been written regarding the histogenesis and microscopic appearance of the neurinomas and we consider it superflous to dwell on the controversial discussion of the subject, as the real origin of these tumors is still debatable. It suffices, then, to mention briefly the current views.

The most plausible explanation about the origin of these tumors is the one proposed originally by von Recklinghausen (28) who suggested their connective tissue origin, a view subsequently supported by Mallory (21), Penfield (27) and Tarlov (30). On the other hand their neuroectodermal origin in the Schwann cells, as advocated by Verocay (31) and later supported by Antoni (1), Masson (22) and Murray and Stout (23), also has its strong points. Cushing (5) took an intermediate view in considering them as a possible transition between neuroglia and connective tissue.

Almost everyone, however, has agreed on their histological appearance. These tumors are primarily composed of two kinds of tissue (12), the compact cellular mass (type A or fibrillar tissue of Antoni) and the loose-meshed tissue (type B or reticulated tissue of Antoni). Their general appearance is furthermore influenced by the age of the growth and subsequent degenerative changes.

That these tumors are morphologically like the peripheral neurofibromas of von Recklinghausen is a known fact. Their only differential point rests on the presence of nerve fibrils in the capsule in the former and in the center of the tumor in the latter. Penfield (26), nevertheless, has also made the remark that the cells in the neurofibromas are more mature, an observation that can hardly be corroborated.

As shown in the accompanying photomicrographs (Fig. 6), all the neurinomas at the angle are histologically the same regardless of their location and of whether or not there was evidence of peripheral neurofibromatosis elsewhere. The variations usually found in acoustic neurinomas are likewise found in the rest and hence a histological differentiation is impossible.

Grossly, however, the bilateral neurinomas and the neurinomas at the recess associated with multiple peripheral neurofibromas were

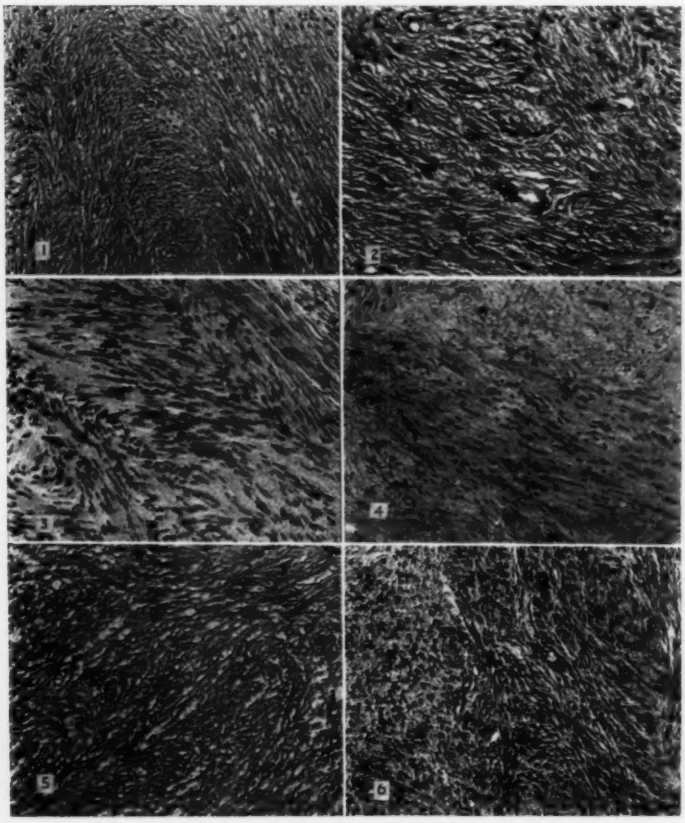

FIG. 6. Photomicrographs of different neurinomas at the cerebellopontile recess. Low power magnification. Hematoxylin and eosin.

1. Unilateral acoustic without peripheral neurofibromas (M. R. 300471)
2. Unilateral acoustic with peripheral neurofibromas (L. Y. 207209)
3. Bilateral acoustic (G. W. 335824)
4. Neurinoma of the Vth N (L. R. 261715)
5. Neurinoma of the Xth N (I. B. 237504)
6. Neurinoma of the XIth N (C. W. 305730)

found in our cases to be harder than the unilateral acustic tumors, in spite of their similar histological appearance. Perhaps this may be

explained by the relative old age of the tumors in the former, if we recall their more prolonged duration of symptoms.

SUMMARY

1. An analysis of one hundred and sixty cases of neurinomas at the cerebellopontile recess has been presented.

2. Their incidence, location, symptoms, signs, operation, operative mortality and end results have been discussed.

3. Emphasis has been placed on the chronology and duration of symptoms, as well as on the average age at onset.

BIBLIOGRAPHY

1. Antonio, N. R. E.: Über Rückenmarkstumoren und Neurofibroma. München und Wiesbaden, 1920.
2. Bárány, R.: Die nervösen Störungen des Cochlear—und Vestibularapparates. Cf. v. Lweandowski Handbuch der Neurologie, Berlin, 1910, **1:** 919–958
3. Cotterill, J. M.: Remarks on the surgical aspects of a case of cerebellopontine tumor by Bruce. Tr. Med. Chir. Soc., Edinburgh, 1898–99, **18:** 215.
4. Cushing, H.: The establishment of cerebral hernia as a decompressive measure for inaccessible brain tumor, with the description of intermuscular methods of making a bone defect in temporal and occipital regions. Surg., Gynec., Obst., 1905, **1:** 297–314.
5. Cushing, H.: Tumors of the Nervus Acusticus and the Syndrome of the Cerebellopontile angle. Philadelphia and London, W. B. Saunders, 1917, 1–278.
6. Dandy, W. E.: An operation for the total extirpation of tumors of the cerebellopontine angle. A preliminary report. The Johns Hopkins Hosp. Bull., 1922, **33:** 344–345.
7. Dandy, W. E.: An operation for the cure of tic douloureux. Partial section of the sensory root at the pons. Arch. Surg., 1929, **18:** 687–734.
8. Dandy, W. E.: The treatment of trigeminal neuralgia by the cerebellar route. Ann. Surg., 1932, **96:** 787–795.
9. Dandy, W. E.: Concerning the cause of trigeminal neuralgia. Am. Jour. Surg., 1934, **24:** 447–455.
10. Dandy, W. E.: An operation for the total removal of cerebellopontine (acoustic) tumors. Surg., Gyn., Obst., 1925, **41:** 129–148.
11. Dandy, W. E.: Removal of cerebellopontine (acoustic) tumors through a unilateral approach. Arch. Surg., 1934, **29:** 337–344.
12. Elsberg, C. A.: Surgical Diseases of the Spinal Cord, Membranes and Nerve Roots. New York, Paul B. Hoeber, Inc., 1941, 238–242.
13. Ford, F. R.: Diseases of the Nervous System in Infancy, Childhood and Adolescence. Springfield, Illinois, Charles C. Thomas, 1944. 2nd Ed., p. 146.

14. Frazier, C. H.: Remarks upon the surgical aspects of tumors of the cerebellum. New York Med. Jour., 1905, **81:** 272–344.
15. Gonzalez-Revilla, A.: Tic douloureux and its relationship to tumors of the posterior fossa. Analysis of twenty-four cases. To be published in Jour. Neurosurg.
16. Hanrahan, E. M., and Dandy, W. E.: A procedure to correct facial paralysis. Jour. Am. Med. Assoc., April 8, 1944, **124:** 1051–1053.
17. Hardy, M., and Crowe, S. J.: Early asymptomatic acoustic tumors. Arch. Surg., 1936, **32:** 292–301.
18. Henschen, F.: Über Geschwülste der hinteren Schädelgrube, insbesondere des Kleinhirnbrückewinkels, 1910, Jena, Gustave Fisher.
19. Jackson, J. H.: Selective Writings. London, Hodder and Stoughton, 1931.
20. Krause, F.: Zur Freilegung der hinteren Felsenbeinflaeche und des Kleinhirns. Beitr. z. klin. Chir., 1903, **37:** 728–764.
21. Mallory, F. B.: The type of cell of the so-called dural endothelioma. Jour. Med. Research, 1919, **41:** 349.
22. Masson, P.: Experimental and spontaneous Schwannomas (peripheral gliomas). Am. Jour. Path., 1932, **8:** 367–414.
23. Murray, M. R., and Stout, A. P.: Schwann cell versus fibroblast as the origin of the specific nerve sheath tumor. Am. Jour. Path., 1940, **16:** 60.
24. Nielsen, A.: Acoustic tumors with special reference to end results and sparing of the facial nerve. Ann. Surg., 1942, **115:** 849–868.
25. Olsen, A., and Horrax, G.: The symptomatology of acoustic tumors with special reference to atypical features. Jour. Neurosurg., 1944, **1:** 371–378.
26. Penfield, W.: Encapsulated tumors of the nervous system. Surg., Gyn., Obst., 1927, **45:** 178.
27. Penfield, W.: Cytology and Cellular Pathology of the Nervous System. New York, Paul B. Hoeber, 1932.
28. Recklinghausen, F. von: Über die multiplen Fibrome der Haut und ihre Beziehung zu den multiplen Neuromen. Festschr. f. Virchow, Berlin, 1882.
29. Stone, R. S., and Schulze, F. J.: Ventricular changes caused by proved tumors of the brain. Amer. Jour. Roentgenol., 1938, **39:** 523–533.
30. Tarlov, I. M.: Origin of the perineurial fibroblastoma. Am. Jour. Path., 1940, **16:** 33–40.
31. Verocay, J.: Multiple Geschwülste als Systemerkrankung am nervösen Apparate. Festschr. f. Chiari, Wien und Leipzig, Braunmuller, 1908, p. 278–415.
32. Wolff, H. G.: Headache mechanisms. A summary. Research Publ. Assoc. for Research Nerv. and Ment. Dis., Williams and Wilkins, Baltimore, 1943, **23:** 176–177.
33. Woolsey, G., Fraenkel, J., Hunt, J., and Elsberg, C.: Contribution to the surgery of neurofibroma of the acoustic nerve, with remarks on the surgical procedure. Ann. Surg., 1904, **40:** 293–319.

PROCEEDINGS OF THE MEETINGS OF THE JOHNS HOPKINS MEDICAL SOCIETY

Held in Hurd Memorial Hall, December 9, 1946

Symposium on Irradiation Therapy in Ophthalmology and Otolaryngology: I. General Considerations of Irradiation. DR. CURTIS F. BURNAM (*Department of Surgery, Johns Hopkins Hospital*).

At the present time, so far as therapy is concerned, only x-ray and radium need to be considered. There are a number of newer forms of irradiation which have proved of value but not in any of the pathological processes found in the nose, throat or eye.

A brief report is presented on the nature of roentgen and radium rays, how they are produced, and how they are measured. The importance of filters in changing the quality of irradiation is discussed for both x-ray and radium. Very briefly, the methods of separating radon from radium are considered. As the question often arises "Why use radium?", "Why use radon?", a discussion of the merits of each of these forms of applying gamma and beta rays is considered. An explanation of the meaning and methods of recording radium and radon dosages is presented. The physical changes that take place in a beam of irradiation in the human body are discussed, as well as the chemical and biological changes induced by the absorption of radium and x-rays. It is pointed out that the effects of different wave lengths are identical and that the effects of beta radiation are the same as those of gamma provided an equal quantity is absorbed in a tissue. Very briefly, methods of protecting the personnel using radium and x-ray are described. The importance of distance and of time of exposure, as well as of heavy screening, is explained. A brief description is given of the nasal applicator used in nose and throat work, particularly in treating lymphoid tissue in the nasopharynx, and of the beta ray applicator used in treating superficial eye conditions.

II. Irradiation of the Nasopharynx. DR. SAMUEL J. CROWE (*Department of Laryngology and Otology, Johns Hopkins Hospital*).

Many of the hearing disorders of adult life begin in childhood, and if we are to learn more about the causes, treatment, and prevention of deafness, we must concentrate our studies on children. Almost every type of middle and inner ear deafness seen in adults is found in children, with this important difference: in children, the impairment is just beginning and opportunities are offered for study of the life history of the disease and for developing some kind of effective and even preventive therapy.

A common cause of impaired hearing in children is frequent upper respiratory infections and hypertrophic lymphoid tissue in and around the pharyngeal orifices

of the Eustachian tubes. In aviators, submariners, and others who work under rapidly changing pressures, acute changes are brought about in the middle ear, due to colds and hypertrophied lymphoid tissue that interferes with the normal function of the Eustachian tubes. In both, the symptoms are due to aerotitis; abrupt and painful in aviators, painless and often asymptomatic in children until secondary changes in the middle ear begin to cause progressive loss of hearing.

Irradiation of the nasopharynx has been practiced in this hospital for nearly 20 years. It is a simple, safe, and inexpensive way to remove lymphoid tissue from locations inaccessible surgically. Thousands of patients have been treated, and many have been followed for 15 years. We are convinced this is a valuable public health measure. If school children from 8 to 10 years of age were examined with otoscope, nasopharyngoscope, tuning forks, voice and audiometer, and those with hypertrophic lymphoid tissue around the orifice of the Eustachian tubes irradiated, we think that disability from deafness later in life could be reduced as much as 50 per cent.

III. Beta Irradiation in Ophthalmology. DR. CHARLES E. ILIFF (*Department of Ophthalmology, Johns Hopkins Hospital*).

Beta rays possess the same qualities as other rays in the power of selective tissue destruction, but in contrast to gamma rays their penetration is shallow. In no single case has any damage to the lens been observed either clinically or experimentally.

Excellent results have been obtained in the treatment of vernal conjuctivitis. Recurrences are less frequent, and when these do occur are less severe.

In anterior ocular tuberculosis beta therapy seems to shorten the course and decrease the severity of the symptoms with less residual scarring of the cornea. Irradiation, though, did not prevent future tuberculous recurrences.

Small benign tumors of the lids and anterior segment can be removed easily and safely and give an excellent cosmetic result.

In corneal scars, where vascularization is a prominent feature and where there is still activity, irradiation appears beneficial. In old, calcified, and dense scars, treatment is not successful.

Superficial vascularization after keratectomy and keratoplasty can be controlled.

Encouraging results are obtained in the treatment of acne rosacea keratitits.

Dystrophies, sarcoid, lupus erythematosus, pemphigus, punctate keratitis, and corneal ulcers due to pyogenic infections, are not improved by beta rays and may be made worse by their use.